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# RESEARCH MEMORANDUM

## SUMMARY OF SPIN AND RECOVERY CHARACTERISTICS OF 12 MODELS OF FLYING-WING AND UNCONVENTIONAL-TYPE AIRPLANES

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RESEARCH MEMORANDUM

# SUMMARY OF SPIN AND RECOVERY CHARACTERISTICS OF 12 MODELS OF FLYING-WING AND UNCONVENTIONAL-TYPE AIRPLANES

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## SUMMARY

A compilation is presented of free-spinning model results of investigations of the spin and recovery characteristics of 12 flying-wing and unconventional-type designs. The results were obtained from dynamic tests in the Langley 15-foot free-spinning tunnel and in the Langley 20-foot free-spinning tunnel which replaced it. Dimensional data, mass data, and three-view drawings of the free-spinning models which correspond to each of the 12 airplane designs are presented. The model test results presented include the spin and recovery characteristics of each model for various combinations of control deflections and for various loadings and dimensional configurations.

The results of the spin-tunnel investigations indicated that the effects of control setting and control movement on the spin and spin-recovery characteristics of the flying-wing and unconventional-type models were affected by changes in mass distribution in the same manner as for models of conventional configurations. For mass distributed chiefly along the fuselage, aileron-with and elevator-up settings were conducive of the best recovery; whereas elevator-down and aileron-against settings were conducive of the slowest recovery; for mass distributed chiefly along the wings, the converse was true. The influence of mass distribution on the effect of directional controls was dependent not only on the yawing moment produced but also on the accompanying rolling moment if the rolling moment was appreciable. Recovery techniques required were similar to those of conventional configurations except where unconventional-type control surfaces set up unusual moments when moved for recovery. The models generally recovered from inverted spins as readily as from erect spins and it was indicated that wing-tip parachutes are an effective means of terminating spins in an emergency. Although the results were not sufficiently extensive for evaluation in the form of a design criterion for satisfactory recovery, the data presented should help designers of flying-wing and unconventional-type airplanes anticipate probable spin and recovery characteristics.

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## INTRODUCTION

The results of investigations of the spin and recovery characteristics of numerous models tested in the Langley 15-foot free-spinning tunnel and the Langley 20-foot free-spinning tunnel during the years 1935 to 1946 have been used to establish empirical criterions for satisfactory spin recovery (references 1 and 2) which are generally applicable to airplanes having mass distributions typical of this time period and which are considered of conventional design (that is, having both horizontal and vertical surfaces at the tail end of the airplane). The results of several designs which may be generally termed unconventional or flying-wing-type configurations were also available and, because of increased interest in unconventional high-speed airplane configurations, it appeared desirable to evaluate these available results to determine criterions for satisfactory spin recovery similar to those evolved for conventional airplanes. Because the flying-wing and unconventional-type designs often utilized unusual and different methods of obtaining directional control, it was not possible to evaluate their spin-recovery characteristics in terms of a vertical-tail design parameter (tail-damping power factor) in the manner used for conventional designs (reference 1). Also, because of rather limited data available for these configurations, an alternate effective parameter could not be developed at this time. Results available for 12 designs of unconventional and flying-wing-type configurations have been summarized, however, and the more important spin and recovery characteristics are presented in this paper.

The effects of mass distribution and center-of-gravity location were determined for many of the models as were the effects of geometric modifications designed in an attempt to improve the spin-recovery characteristics. The investigations included the determination of the effectiveness for spin recovery of several types of controls which are peculiar to flying-wing and unconventional-type airplanes.

The spin and recovery characteristics of each model are presented for the various control configurations, mass distributions, and dimensional configurations tested. Dimensional data, mass data, and a three-view drawing of each of the various free-spinning models are included. The data presented are intended to help designers of unconventional and flying-wing-type airplanes anticipate probable spin and recovery characteristics.

## SYMBOLS

| | |
|---|---|
| b | wing span, feet |
| S | wing area, square feet |

$\bar{c}$ — mean aerodynamic chord, inches

$c$ — wing local chord, inches

$x/\bar{c}$ — ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord; positive when center-of-gravity position is rearward of leading edge of $\bar{c}$

$z/\bar{c}$ — ratio of distance between center of gravity and thrust line or fuselage reference line to length of mean aerodynamic chord; positive when center of gravity is below thrust line

$m$ — mass of airplane, slugs

$\rho$ — air density, slug per cubic foot

$\mu$ — airplane relative density $(m/\rho Sb)$

$I_X, I_Y, I_Z$ — moments of inertia about X, Y, Z body axes, respectively, slug-feet$^2$

$\frac{I_X - I_Y}{mb^2}$ — inertia yawing-moment parameter

$\frac{I_Y - I_Z}{mb^2}$ — inertia rolling-moment parameter

$\frac{I_Z - I_X}{mb^2}$ — inertia pitching-moment parameter

$\alpha$ — angle between thrust line or fuselage reference line and vertical, degrees, approximately equal to absolute value of angle of attack at plane of symmetry

$\phi$ — angle between span axis and horizontal, degrees; on the charts U or D means inboard wing (right wing in a right spin) up or down, respectively, with relation to the horizontal

$V$ — full-scale true rate of descent, feet per second

$\Omega$ — full-scale angular velocity about spin axis, revolutions per second

| | |
|---|---|
| $\delta_r$ | deflection of rudder, degrees |
| $\delta_e$ | deflection of elevator, degrees |
| $\delta_a$ | deflection of ailerons, degrees |
| U | elevator up |
| N | elevator neutral |
| D | elevator down |
| $\Delta C_l$ | rolling-moment coefficient due to control deflection $\left(\text{Rolling moment}/\frac{1}{2}\rho V^2 bS\right)$ |
| $\Delta C_n$ | yawing-moment coefficient due to control deflection $\left(\text{Yawing moment}/\frac{1}{2}\rho V^2 bS\right)$ |

## MODELS

The dimensional and mass characteristics of the airplanes simulated by the models are presented in tables I and II, respectively. Three-view drawings of the models are presented in figure 1. The models were constructed as described in reference 3. Briefly, each model was constructed primarily of balsa to be dimensionally similar and was ballasted with lead weights to be dynamically similar to the particular airplane it represented at a given test altitude. A remote-control mechanism was installed in the model to actuate the controls for recovery tests. Sufficient moments were exerted on the control surfaces during recovery tests to move the controls rapidly to the desired positions without regard to the actual forces required to move the controls of the airplane. Parachutes used for spin-recovery parachute tests were of the flat circular type, made of silk, and had drag coefficients of approximately 0.7 based on the surface area of the canopy when spread out flat.

The lateral and longitudinal controls for some of the models presented herein are combined in one pair of control surfaces designated as elevons. Longitudinal control is obtained by deflection of the elevons together and lateral control is obtained by differential deflection of the elevons. In this paper, elevon deflections for longitudinal and lateral control will be referred to, generally, as elevator and aileron deflections, respectively.

Wind Tunnel and Testing Techniques

The model tests were performed in the Langley 15-foot free-spinning tunnel and in the Langley 20-foot free-spinning tunnel which replaced it. The operation of the Langley 15-foot free-spinning tunnel is described in reference 3 and operation of the Langley 20-foot free-spinning tunnel is generally similar. In brief, models are launched with rotation into the vertically rising air stream of the tunnel and the airspeed is varied by the operator until it equals the rate of descent of the model. The model is thus maintained at approximately eye level in the test section. With the model spinning freely, observations of its general behavior are made, and motion-picture records are obtained. Figure 2 shows a typical model spinning in the Langley 20-foot free-spinning tunnel. After observation of the fully developed spin, recoveries are attempted. The turns for recovery are measured from the time the controls are moved to the time the spin rotation ceases.

Spin tests generally are made to determine the spin and recovery characteristics of the model for the normal spinning control configuration (elevator full up, ailerons neutral, and rudder full with the spin) and at various other aileron-elevator combinations including neutral and maximum deflections. The control deflections used were measured perpendicular to the hinge lines. Recoveries are generally attempted by rapid full rudder reversal, although for the investigations presented herein, some recoveries were attempted by other control manipulations which are specifically noted on the charts. For spins which had rates of descent in excess of that which could be readily attained in the tunnel, the rate of descent was recorded as greater than the velocity at the time the model hit the safety net, as >300. For recovery attempts in which the model struck the safety net before recovery could be effected, because of the wandering or oscillatory nature of the spin or because of an unusually high rate of descent, the number of turns from the time the controls were moved to the time the model struck the safety net was recorded. This number indicates that the model required more turns to recover from the spin than shown, as, for example, >3. A >3-turn recovery, however, does not necessarily indicate an improvement over a >7-turn recovery. The symbol ∞ is used on the charts to indicate that recovery required more than 10 turns. For a condition in which the model recovered without movement of the controls after having been launched in a spinning attitude with the controls set for a spin, the result is recorded on the charts as "no spin."

The recovery characteristics of a model have been considered satisfactory if recovery from the spin at the normal spinning control configuration (rudder full with, elevator full up, and ailerons neutral) requires 2 turns or less and if small deviations from this control configuration do not cause recovery to exceed $2\frac{1}{4}$ turns. Small deviations are considered to be those which allow for a variation in the deflection of any given control setting by as much as one-third from its intended position. This criterion for satisfactory spin recovery has been adopted on the basis of full-scale-airplane spin-recovery data and corresponding model test results (reference 4). The full-scale results available in reference 4 were generally for conventional-type airplanes with horizontal tails, but unless actual full-scale spins of unconventional or flying-wing type airplanes subsequently prove otherwise, it is felt that the criterion for satisfactory recovery specified may be generally applicable to all types of airplane designs. Unpublished observation of airplane motions for some of the unconventional and flying-wing-type configurations presented herein have indicated that the model results give qualitative agreement, at least, with the motions obtained on the airplanes.

The spin-recovery parachute tests were performed in the manner described in reference 5. In brief, recoveries were generally attempted by parachute action alone, the rudder being maintained with the spin. The parachutes were opened by use of a remote-control mechanism.

## PRECISION

The results of the free-spinning-tunnel tests presented are believed to be the true values given by the model within the following limits:

| | |
|---|---|
| $\alpha$, deg | $\pm 1$ |
| $\phi$, deg | $\pm 1$ |
| V, percent | $\pm 5$ |
| $\Omega$, percent | $\pm 2$ |
| Turns for recovery: | |
| From motion-picture records | $\pm \frac{1}{4}$ |
| From visual estimate | $\pm \frac{1}{2}$ |

All recoveries presented herein were obtained from motion-picture records expect where otherwise specifically noted on the charts.

The preceding limits may have been exceeded for certain spins in which it was difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin. Comparison between model and airplane spin results (reference 4) indicates that spin-tunnel results are not always in complete agreement with airplane results. In general, when the model spun at an angle of attack less than $45^{\circ}$ the corresponding airplane spun at a larger angle of attack, and when the model spun at an angle of attack greater than 45°, the corresponding airplane spun at a smaller angle of attack. Generally, the spin at the lower angle of attack (either model or airplane) was associated with the higher rate of descent. The airplane generally spun with its inner wing down more than the inner wing of the corresponding model. The comparison made in reference 4 for 60 different designs indicated that approximately 90 percent of the models satisfactorily predicted full-scale recovery characteristics and that the remaining 10 percent of the models were of some value in predicting details of the full-scale results such as proper recovery technique, aileron effects, and the motion in the developed spin. The designs compared in reference 4 were, in general, for conventional airplanes.

The accuracy of measuring the weight and mass distribution of the models is believed to be within the following limits:

| | |
|---|---|
| Weight, percent . . . . . . . . . . . . . . . . . . . . . . . . . . | ±1 |
| Center-of-gravity location, percent $\bar{c}$ . . . . . . . . . . . . . . . . | ±1 |
| Moments of inertia, percent . . . . . . . . . . . . . . . . . . . . . | ±5 |

The controls were set with an accuracy of ±1°.

## TEST CONDITIONS

The variations of the mass-distribution parameters for the various loadings investigated for each model are presented in figure 3. Figure 4 shows the variations of the control-surface deflections with stick positions for the models which combined the longitudinal and lateral controls in one control surface. The dimensional modifications tested during the investigations summarized in this paper are presented in figure 5. Figure 6 shows the original rudders tested on models 1 to 4, these rudders are of the drag type and are mounted at the wing tips. The control configurations tested on each specific model for each model configuration are indicated in charts 1 to 14 with the results.

## RESULTS AND DISCUSSION

The erect spin and recovery data for the 12 models summarized herein are presented in charts 1 to 12. Inverted spin data and spin-recovery parachute data available for some of the 12 models are presented in charts 13 and 14, respectively. The results of tests with dimensional modifications on the various models are listed with their indicated effectiveness in table III and in general are presented in the corresponding charts 1 to 12.

Erect Spins

The spin and recovery characteristics of models 1 to 6 (charts 1 to 6) were found to be in general agreement with references 1 and 6 as regards the influence of the mass distribution on the effectiveness of the controls during the spin and the recovery. When the mass of the models was distributed primarily along the wings, for example, aileron settings against the spin (stick left in a right spin) and down-elevator settings (stick forward) were generally favorable. For these control settings, steeper spins with more rapid recoveries were generally obtained than were obtained for other control settings. These control settings were also conducive of no-spin conditions. For this mass distribution, reversal of rudders which primarily gave a yawing moment only were ineffective; whereas movement of the elevator down appeared to be the most effective method of obtaining recovery. Such control movement for recovery is consistent with that indicated for conventional airplanes for similar loadings. When the mass of the models was distributed primarily along the fuselage, aileron-with settings and elevator-up settings were generally most effective in causing steep spins from which recovery was most easily obtained. For this mass distribution, movement of the rudder against the spin, when the rudder primarily gave a yawing moment only, generally appeared to be the most effective method of obtaining recovery. These results of control effectiveness are also consistent with those indicated for conventional airplanes for similar loadings (references 1 and 6).

Some exceptions to the general effects of control settings and movements on the spin and recovery were obtained, however. When, for example, model 6 had its loading distributed mainly along the wings (chart 6) full-down elevator and full ailerons against the spin sometimes caused a relatively flat spin from which recovery was unsatisfactory. For this model and other similar models, combination of the longitudinal and lateral controls in a single surface caused unusually large deflections of the surfaces when both full elevator and aileron controls were applied. When the elevator was full down and the ailerons were full against the spin, the inboard control surface (that on the right wing in a right spin) had a large downward deflection; whereas the outboard control surface was nearly neutral. It is believed that this large downward deflection of the inboard control caused unusually large pro-spin yawing moments which overcame the possible favorable effect of the rolling moment due to the aileron-against setting. For loadings for which the mass was distributed primarily along the fuselage, control settings of the elevator full up and the ailerons full with the spin tended to be similarly detrimental.

Models 1 to 4 (charts 1 to 4) had rudders which did not primarily provide yawing moments only but also provided appreciable rolling moments. The rudders for models 1 to 4 are shown in figure 6. Typical of these rudders are those of models 2 and 3, similar models with different rudders. The rudder of model 2 is a spoiler-like surface which on the airplane protruded downward and forward through the lower surface of the wing; a pitch flap moved upward in conjunction with downward movement of the spoiler surface. On model 3 two split flap-like surfaces, one on the upper surface and one on the lower surface of the wing, were both deflected for rudder movement. For both models, the rudders on the right wing functioned and those on the left wing remained neutral for a right turn. These rudders may generally be termed scoop-type and split-type rudders, respectively.

A comparison of the aerodynamic yawing- and rolling-moment characteristics of the two general types of rudders (measured on the free-flight-tunnel balance, described in reference 7) is shown in figure 7. The results indicate that, for angles of attack above $34^{\circ}$, setting the rudder against the spin (left rudder pedal forward in a right spin) for the scoop-type rudder produced a rolling-moment increment in the same direction as would be obtained by setting the ailerons against the spin (left stick in a right spin); whereas for the split-type rudder, a rolling-moment increment in the same direction as would be obtained by setting the ailerons with the spin was produced. The yawing moments contributed by both types of rudders were approximately the same. The results are consistent with those indicated in reference 6 for conventional designs with loadings with the mass distributed primarily along the wings in that rolling moments caused by aileron-against settings were favorable and rolling moments caused by aileron-with settings were unfavorable to spin recovery. Thus for wing-heavy loadings, the scoop-type rudders when moved against the spin gave favorable rolling moments for spin recovery and the split-type rudders when moved against the spin produced unfavorable rolling moments. Conversely, it was indicated that maintaining the split-type rudders with the spin was favorable for spin recovery; whereas maintaining the scoop-type rudders with the spin was unfavorable. As is further indicated in reference 6, for loadings in which the mass is distributed primarily along the fuselage, aileron-with settings are favorable. It appears probable that, for designs with the loading primarily along the fuselage, scoop-type rudders when set against the spin would have produced unfavorable rolling moments for spin recovery; whereas split-type rudders would have produced favorable rolling moments.

Models 5 and 6 had rudder control surfaces that primarily provided a yawing moment only. Model 5 had dual rudders and model 6 was tested both with single and dual rudders. For models 5 and 6 (charts 5 and 6), when the mass distribution was primarily along the fuselage, rudder reversal was generally effective in producing recovery; whereas for model 6, rudder reversal was ineffective in producing recovery when the mass distribution was primarily along the wings. These results are in accord with the results of reference 1 for conventional airplane designs. Thus rudders which primarily provided yawing moment only appear to be similarly effective in producing recovery for airplanes of the flying-wing type as for airplanes of conventional designs, depending primarily on mass distribution. It has been noted for one model (model 6) that single or dual vertical tails appeared equally as effective provided they had equivalent vertical-tail volume (reference 8).

Model 7 had a delta-wing plan form and a loading for which the weight was very heavily distributed along the fuselage. The results of an extensive investigation on model 7 (reference 9) indicate that spins may not be obtained for values of the inertia yawing-moment parameter $\left(I_X - I_Y/mb^2\right)$ between approximately $-450 \times 10^{-4}$ to $-750 \times 10^{-4}$ and that flat spins will generally be obtained for larger or smaller values of the inertia yawing-moment parameter. Reversal of the rudder was generally ineffective in stopping the spin rotation except when sufficiently large dual vertical tails and rudders were used (reference 9). These large vertical tails are shown in figure 5 and the results are noted in table III. Movement of the ailerons with the spin, however, was generally effective for terminating the spin rotation. This effect is in agreement with the results obtained during an extensive investigation on a swept-wing model having a horizontal tail. This model was tested at fuselage heavy mass distributions (reference 10) beyond the mass range of references 1 and 6. For all loading conditions tested on model 7 after spin rotation had ceased, the model tended to glide at a flat attitude (very high angle of attack) decreasing its angle of attack relatively slowly except when the elevator was full down.

Model 8 had a sweptforward wing and generally tended to spin flat with a wide radius, very slow rotation, and large oscillations in roll, pitch, and yaw (chart 8). Rudder reversal generally stopped the rotation but the model tended to glide at very large angles of attack above the stall and the oscillations continued after the rotation ceased. When the elevator was reversed to full down following rudder reversal, however, the model tended to dive after the spin rotation ceased. Unpublished full-scale results on this design indicated that accurately timed movement of the stick forward during the oscillations was required to regain unstalled flight. The results of an extensive investigation of modifications to this design and a brief comparison with flying-wing types with sweptback wings indicate that major modifications would be needed to improve the characteristics of this design and that in this instance the sweptforward wing appeared to cause the unsatisfactory trim characteristics. Installation of a large horizontal tail and increased vertical-tail length made the model's trim and spin characteristics satisfactory. The results with the horizontal tail installed are noted in table III and the modification is shown in figure 5.

Models 9 and 10 were similar designs having approximately circular plan form, dual vertical tails mounted on the upper surface of the wing, and horizontal surfaces with control surfaces extending from the nearly circular plan form for longitudinal and lateral control. The spin and recovery characteristics of model 9 (chart 9) were not appreciably affected by changes in mass distribution for the range of values of inertia yawing-moment parameter tested $\left(I_X - I_Y/mb^2 \text{ from } -208 \times 10^{-4} \text{ to } 590 \times 10^{-4}\right)$. Increasing the relative density for model 9, however, had an adverse effect upon spin recovery. The results for the largest relative density for model 9 and the results for model 10 (chart 10) which were for a similarly large relative density, indicated poor recovery characteristics. Satisfactory spin recoveries were obtained for model 9 by a special technique for which the leading edges of the horizontal surfaces were moved down and the stick was held back and moved against the spin (left in a right spin) while the rudder was reversed. Satisfactory recoveries were obtained on model 10 only with the installation of modifications and following a recovery technique in which the stick was held full back and moved against the spin while the rudder was reversed, a technique similar to that used for model 9. The satisfactory modifications used for model 10 were a supplementary vertical tail (supplementary tail 2, fig. 5(g)) behind the trailing edge, a large semispan spoiler (spoiler no. 4, fig. 5(g)) beneath the outer wing in a spin (left wing in a right spin), or two large vertical fins (vertical fin 7, fig. 5(g)) mounted on the horizontal control surfaces.

Models 11 and 12 were tail-first or canard-type designs. The spinning characteristics of these models (charts 11 and 12) were not affected by small variations in mass distribution or by small movements of the center of gravity. After recovery from the spin, model 11 trimmed at a high angle of attack (approx. $80^{\circ}$) even when the elevator was set to simulate a stick position of full forward. Modifications which caused model 11 to trim in a normal flight attitude after the spinning rotation had been stopped were the addition of large fillets or drooping enlarged ailerons $22^{\circ}$. Prior to spin tests, model 12 was designed so that it would not trim at high angles of attack by installing a large elevator with increased deflections over those of model 11, and by installing large wingtip trimmers. The configuration for model 12 with these changes is shown in figure 1($l$). Satisfactory spin recoveries in which the model recovered in a dive were obtained for model 12 by application of full rudder reversal when the elevator was set to simulate a stick position of full forward.

Inverted Spins

Inverted spin and recovery characteristics were available for 10 of the 12 models presented herein. These results are presented in chart 13. A brief analysis of the results based on reference 11, a summary of inverted spin results, is presented.

When the ailerons were set with the spin, for the fully developed inverted spins presented, the ailerons were set to simulate a stick position to the pilot's left when spinning to the pilot's right with the rudder to the pilot's right (controls crossed). When the ailerons were set against the inverted spin, the controls were together. Elevator-up simulated stick forward and elevator-down simulated stick back. In chart 13, the angle of wing tilt is given as up or down relative to the ground.

Model 1 would spin inverted only when the ailerons were neutral or with the spin. Recoveries from these spins were generally unsatisfactory. The inverted spin results were generally similar to those for erect spins. This is probably an indication that exposed area which tended to damp the rotation was approximately the same for both erect and inverted spins.

Model 2 would spin inverted only when the ailerons were with the spin with the stick neutral or forward longitudinally. The inverted spin characteristics were considered somewhat improved over the erect spin characteristics in that spins were obtained for fewer control settings (that is, more no-spin conditions were obtained).

Model 4 would generally not spin inverted when the rudders were set with the spin (right rudder pedal forward in an inverted spin to the pilot's right); whereas it did spin erect. Model 4, however, would spin inverted, when the rudders were set against the spin (data not presented).

Model 5 would spin inverted for most control configurations; recovery by rudder reversal was, however, satisfactory. These results are somewhat better than those obtained erect, probably because more vertical fin and rudder area were unshielded in the inverted spin than in the erect spin.

Model 6 would spin inverted only with ailerons and rudder with the spin. Satisfactory recoveries were obtained by neutralizing all of the controls.

Model 7 would spin inverted for a loading condition for which it would not spin erect. The model spun inverted, however, only when the ailerons were against the spin and the stick was neutral or forward longitudinally. The rudder of this model was above the wing and shielded in erect spins, whereas it was relatively unshielded in inverted spins. Thus for this design it appears that in an erect attitude the rudder which was shielded did not supply sufficient pro-spin yawing moment to cause the model to rotate; whereas in an inverted attitude the pro-spin yawing moment of the unshielded rudder was apparently sufficient to cause the model to spin. Satisfactory recovery by rapid rudder reversal was obtained and it appears that, on a corresponding airplane, neutralization of the stick laterally and longitudinally also would be desirable.

Model 8 would generally not spin inverted but tended to become erect and, as in the case of erect spins, tended to remain at a flat erect attitude. The vertical fin and rudder of this design, which had a relatively large aspect ratio and was mounted well above the fuselage center line, was unshielded in the inverted attitudes and may have contributed a rolling moment which caused the model to roll erect following launching into the tunnel inverted.

Model 10 had inverted spins which were similar to the erect spins, recoveries from which were unsatisfactory.

Models 11 and 12 would spin inverted generally when the ailerons were neutral or with the spin. Reversal of the rudder caused the spinning rotation to stop quickly for both models. Model 11 remained in an inverted stalled attitude after the rotation had ceased, for all elevator settings. Model 12, however, dived into a normal flight attitude when the elevator was set to cause a nose-down pitching moment from the inverted attitude. These results are similar to those for erect spins.

The results of the inverted spin tests of the various models are in general accord with inverted spin and recovery results for conventional designs as indicated in reference 11, in that rearward movement of the stick, and aileron-against settings generally tended to be beneficial.

## Spin-Recovery Parachutes

The results of investigations made to determine the effect of spin-recovery parachutes were available for six of the models. The results (chart 14) indicate that, in general, parachutes attached to the outer wing tip in a spin (left wing in a right spin) will generally cause satisfactory spin recovery by parachute action alone for emergency purposes. The primary disadvantage of wing-tip spin-recovery parachutes is the danger of opening the parachute on the inboard wing tip (right tip in a right spin) rather than the outboard wing tip. Under such circumstances, the spin may be flattened and recovery made impossible. The results of tests for conventional designs (reference 12) and for one model reported herein indicated that use of parachutes on both wing tips when opened simultaneously required parachutes of approximately twice the diameter of a single wing-tip parachute used only on the outer wing tip.

Opening two parachutes simultaneously has the advantage of eliminating the danger of opening the wrong wing-tip parachute. The experimental results indicated that a towline length equal to approximately the semispan of the wing should be used.

Model 8 was tested only with a parachute attached to the tail cone for which satisfactory recoveries were obtained. On model 10 a single wing-tip parachute, required for satisfactory recovery, was excessively large but satisfactory recoveries were obtained by simultaneously opening moderate sized tail and wing-tip parachutes. The tail parachute was mounted on the arresting gear mast shown in figure 8.

Reference 12 presents a method whereby the size wing-tip parachute required for satisfactory spin recovery may be calculated. As is indicated in reference 12, calculations by this method correlate satisfactorily with experimental data for flying-wing-type configurations.

## CONCLUSIONS

Based on the spin and recovery characteristics of models of 12 flying-wing and unconventional-type designs investigated in the Langley 15-foot free-spinning tunnel and the Langley 20-foot free-spinning tunnel, the following conclusions are made.

1. The effect of aileron and elevator control settings on spin and recovery characteristics was generally dependent upon mass distribution in the same manner as for conventional configurations: that is, for mass distributed chiefly along the fuselage, aileron-with and elevator-up settings were conducive of the best recovery, whereas elevator-down and aileron-against settings were conducive of the slowest recovery; for mass distributed chiefly along the wings, the converse was true. The influence of mass distribution on the effect of directional controls was dependent not only on the yawing moment produced but also on the accompanying rolling moment if the rolling moment was appreciable.

2. Recovery from inverted spins generally was obtained as readily as from erect spins. It appears that the most rapid recoveries from inverted spins would have been obtained by movement of the stick back longitudinally and against the spin laterally and of the rudder against the spin.

3. A single wing-tip parachute on the outer wing tip in a spin generally was an effective spin-recovery device for emergency recovery of unconventional and flying-wing-type designs.

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TABLE I.- DIMENSIONAL CHARACTERISTICS OF MODELS TESTED

[Model values are presented in terms of corresponding airplane values.]

| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model scale | 1/16 | 1/20 | 1/57.33 | 1/16 | 1/17.54 | 1/20 | 1/20 | 1/17.8 | 1/16 | 1/16 | 1/16 | 1/16.95 |
| Over-all length, ft | 23.58 | 17.78 | 50.90 | 14.25 | 36.44 | 20.45 | 41.37 | 29.40 | 26.64 | 28.13 | 27.40 | 29.58 |
| Wing: | | | | | | | | | | | | |
| Span, ft | 40.59 | 60.00 | 172.00 | 39.00 | 38.67 | 26.83 | 29.42 | 54.0 | 23.33 | 23.33 | 36.98 | 40.57 |
| Area, sq ft | 309.32 | 490.0 | 4020.0 | 293.31 | 496.00 | 200.00 | 375.0 | 356.0 | 427.5 | 427.0 | 191.0 | 208.3 |
| Aspect ratio | 5.33 | 7.36 | 7.36 | 5.19 | 3.01 | 3.60 | 2.31 | 8.20 | 1.27 | 1.27 | 7.00 | 7.91 |
| Root chord, in. | 148.48 | 157.00 | 450.00 | 141.65 | 194.00 | 123.00 | 305.80 | 116.40 | 280.16 | 280.16 | 92.00 | 92.00 |
| Tip chord, in. | 24.80 | 39.00 | 112.00 | 35.92 | 116.00 | 4.28 | 0 | 44.00 | --- | --- | 35.50 | 33.55 |
| Taper ratio | 0.167 | 0.248 | 0.249 | 0.253 | 0.600 | 0.420 | 0 | 0.376 | --- | --- | 0.386 | 0.364 |
| M.A.C., ($\bar{c}$), in. | 103.04 | 109.80 | 315.00 | 102.33 | 157.0 | 93.68 | 203.89 | 85.82 | 238.00 | 238.00 | 67.71 | 67.69 |
| L.E. $\bar{c}$ rearward L.E. root chord | 53.28 | 69.70 | 200.00 | 49.30 | 83.56 | 62.48 | 101.91 | -30.00 | 10.5 | 10.02 | 57.0 | 61.08 |
| Twist, deg | 3.0 | 4.0 | 4.0 | 0 | 0 | --- | 0 | 0 | 0 | 0 | 2.0 to -0.25 | 3.0 to -0.5 |
| Dihedral, deg | Tip -43.0 Center 8.0 | 2.0 | 2.0 | 1.0 | 0 | 0 | 0 | 2.0 | 0 | 0 | 4.5 | 4.5 |
| Sweepback, deg | 29.3 LEW | 21.9 c/4 | 25.8 LEW | 27.8 LEW | 35 c/4 | 38.1 c/4 | 60 LEW | -15 c/4 | 0 c/4 | 0 c/4 | 28.5 c/4 | 28.8 c/4 |
| Airfoil section, root | NACA 66,2-018 | NACA 65,3-019 | NACA 65,3-019 | NACA 66,2-018 | CVA 4-(00) -(12)(40) -(1.1)(1.0) | NACA 0010-64 (normal to 40-percent chord line) | NACA $65_{(06)}$-006.5 | NACA 23018 | NACA 0016 | NACA 0016 | C-W 6500-0015 | C-W 6500-0015 |
| Airfoil section, tip | NACA 66,2x-012 | NACA 65,3-018 | NACA 65,3-018 | NACA 66,2-018 | CVA 4-(00) -(12)(40) -(1.1)(1.0) | ---do--- | NACA $65_{(06)}$-006.5 | NACA 23012 | NACA 0016 | NACA 0016 | C-W 6500-0015 | C-W 6500-0015 |
| Horizontal tail: | | | | | | | | | | | | |
| Span, percent b/2 | None | None | None | None | None | None | None | None | 64.90 | 80.35 | 44.60 | 55.20 |
| Area, sq ft | --do-- | --do-- | --do-- | --do-- | --do-- | --do-- | --do-- | --do-- | 46.0 | 48.0 | 15.56 | 21.52 |
| Longitudinal control: | | | | | | | | | | | | |
| Type | Elevons | Elevons | Elevons | Elevons | Elevons | Elevons | Elevons | Elevator | Elevons | Elevons | Elevator | Elevator[a] |
| Area, sq ft | 36.06 | 31.85 | 273.36 | 32.67 | 54.40 | 16.98 | 33.30 | 36.31 | 25.00 | 47.99 | 15.56 | 18.62 |
| Distance to c.g., ft[b] | 5.76 | 4.55 | 16.85 | 5.03 | 12.76 | --- | 10.53 | 5.42 | 10.42 | 11.45 | 15.73 | 16.05 |
| Vertical tail: | | | | | | | | | | | | |
| Area, sq ft | 31.82 | 0 | 0 | 37.15 | 122.40 | 20.10 | 67.00 | 43.50 | 28.30 | 28.42 | 25.20 | 27.80 |
| Rudders: | | | | | | | | | | | | |
| Type | Frise | Drag | Drag | Drag | Conventional | Conventional | Conventional | Conventional | Conventional | Conventional | Conventional | Conventional |
| Area, sq ft | [c]13.88 | [c]14.63 | [c]120.00 | [c]21.68 | [c]32.00 | 4.10 | 13.40 | 19.40 | [c]13.20 | [c]11.28 | [c]11.44 | [c]13.00 |
| Dist. to c.g., ft[b] | 7.18 | 7.68 | 22.05 | 5.65 | 15.15 | 9.33 | 11.86 | 12.31 | 15.00 | 12.53 | 5.00 | 7.92 |
| Lateral control: | | | | | | | | | | | | |
| Type | Elevons | Elevons | Elevons | Elevons[d] | Elevons | Elevons | Elevons | Conventional | Elevons | Elevons | Conventional | Conventional |
| Span, percent b/2 | 56.66 | 33.67 | 40.00 | 58.30 | 47.20 | 45.40 | 72.15 | 52.85 | 64.90 | 80.35 | 38.01 | 39.11 |
| Area, sq ft | 36.06 | 31.85 | 273.36 | 32.67 | 54.40 | 16.98 | 33.30 | 31.60 | 25.00 | 47.99 | 13.20 | 15.16 |
| Maximum control deflections: | | | | | | | | | | | | |
| Right $\delta_r$, deg up[e] | 90 | [f]26 | 60 | 45 | 25 R | 30 | 30 R | 25 R | 30 R | 25 R | 30 R | 40 R |
| Right $\delta_r$, deg down[e] | 20 | 69 | 60 | 45 | 25 L | 30 | 30 L | 25 L | 30 L | 25 L | 30 L | 11 L |
| Left $\delta_r$, deg up[e] | 90 | [f]26 | 60 | 45 | 25 R | 30 | | | 30 R | 25 R | | 11 R |
| Left $\delta_r$, deg down[e] | 20 | 69 | 60 | 45 | 25 L | 30 | | | 30 L | 25 L | | 40 L |
| $\delta_e$, deg up[e] | 30 | 24 | 20 | [g]10.5, [h]21 | 30 | 20 | 20 | 30 | 15 | 45 | 30 | 60 |
| $\delta_e$, deg down[e] | 20 | 11 | 10 | [g]10.5, [h]7 | 20 | 10 | 20 | 20 | 15 | 15 | 15 | 60 |
| $\delta_a$, deg up[e] | 30 | 17 | 15 | [g]10.5, [h]10 | 15 | 15 | 15 | 20 | 30 | 10 | 20 | 38 |
| $\delta_a$, deg down[e] | 15 | 13 | 15 | [g]10.5, [h]10 | 15 | 15 | 15 | 15 | 30 | 10 | 14 1/2 | 9 |

[a]All movable elevator.

[b]Distances measured rearward to midpoint of control hinge line.

[c]Area of both rudders.

[d]Elevon balancers were used in conjunction with elevon, deflections $\pm 20^\circ$ ($14^\circ$ up and $42^\circ$ down revised).

[e]Deflections measured from chord plane and perpendicular to hinge line.

[f]Deflection of pitch flap which moved up in conjunction with downward movement of drag rudder.

[g]Original deflections

[h]Revised deflections.

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TABLE II.- MASS CHARACTERISTICS OF MODELS TESTED

[Model values are presented in terms of full-scale values]

| Loading | Weight (lbs) | Center-of-gravity location | | Relative airplane density, $\mu$ | | Moments of inertia (slug-feet$^2$) | | | Mass parameters | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $x/\bar{c}$ | $z/\bar{c}$ | Sea level | Test altitude | $I_X$ | $I_Y$ | $I_Z$ | $\frac{I_X - I_Y}{mb^2}$ | $\frac{I_Y - I_Z}{mb^2}$ | $\frac{I_Z - I_X}{mb^2}$ | |
| Model 1 | | | | | | | | | | | | |
| A | 10,194 | 0.128 | -0.003 | 10.59 | 12.62 | 9,313 | 6,834 | 15,635 | $48 \times 10^{-4}$ | $-169 \times 10^{-4}$ | $121 \times 10^{-4}$ | Loading primarily along wings |
| B | 10,194 | .128 | -.003 | 10.59 | 12.62 | 7,264 | 6,834 | 13,586 | 8 | -129 | 121 | Do. |
| C | 10,194 | .128 | -.003 | 10.59 | 12.62 | 11,828 | 6,834 | 18,150 | 96 | -217 | 121 | Do. |
| D | 10,194 | .128 | -.003 | 10.59 | 12.62 | 9,313 | 5,604 | 14,405 | 71 | -169 | 98 | Do. |
| E | 10,194 | .128 | -.003 | 10.59 | 12.62 | 9,313 | 9,226 | 18,027 | 2 | -169 | 167 | Do. |
| F | 10,194 | .188 | -.003 | 10.59 | 12.62 | 9,313 | 6,834 | 15,635 | 48 | -169 | 121 | Do. |
| G | 10,194 | .078 | -.003 | 10.59 | 12.62 | 9,313 | 6,834 | 15,635 | 48 | -169 | 121 | Do. |
| H | 9,755 | .179 | -.023 | 10.14 | 12.01 | 8,417 | 12,417 | 20,667 | -80 | -165 | 245 | Loading primarily along fuselage |
| Model 2 | | | | | | | | | | | | |
| A | 6,526 | 0.290 | -0.040 | 2.91 | 4.62 | 19,138 | 2,274 | 21,298 | $231 \times 10^{-4}$ | $-260 \times 10^{-4}$ | $29 \times 10^{-4}$ | Loading primarily along wings |
| B | 6,526 | .290 | -.040 | 2.91 | 4.62 | 22,951 | 2,274 | 25,111 | 283 | -312 | 29 | Do. |
| C | 6,526 | .290 | -.040 | 2.91 | 4.62 | 19,138 | 1,999 | 21,023 | 235 | -261 | 26 | Do. |
| D | 6,768 | .290 | -.040 | 3.01 | 4.78 | 19,132 | 2,967 | 21,997 | 214 | -251 | 37 | Do. |
| E | 6,694 | .240 | -.040 | 2.98 | 4.73 | 19,132 | 2,679 | 21,709 | 221 | -254 | 33 | Do. |
| F | 6,675 | .320 | -.040 | 2.96 | 4.71 | 19,132 | 2,059 | 21,089 | 229 | -255 | 26 | Do. |
| G | 6,538 | .350 | -.040 | 2.91 | 4.62 | 19,132 | 1,729 | 20,758 | 238 | -260 | 22 | Do. |
| H | 6,914 | .250 | -.040 | 3.08 | 4.89 | 19,131 | 2,919 | 21,949 | 210 | -246 | 36 | Do. |
| Model 3 | | | | | | | | | | | | |
| A | 155,000 | 0.275 | -0.014 | 2.93 | 5.50 | 3,380,000 | 433,500 | 3,769,000 | $207 \times 10^{-4}$ | $-234 \times 10^{-4}$ | $27 \times 10^{-4}$ | Loading primarily along wings |
| B | 155,000 | .275 | -.014 | 2.93 | 5.50 | 3,380,000 | 563,550 | 3,899,050 | 198 | -234 | 36 | Do. |
| C | 155,000 | .333 | -.014 | 2.93 | 5.50 | 3,380,000 | 433,500 | 3,769,000 | 207 | -234 | 27 | Do. |
| D | 155,000 | .391 | -.014 | 2.93 | 5.50 | 3,380,000 | 433,500 | 3,769,000 | 207 | -234 | 27 | Do. |
| E | 155,000 | .200 | -.014 | 2.93 | 5.50 | 3,380,000 | 433,500 | 3,769,000 | 207 | -234 | 27 | Do. |
| Model 4 | | | | | | | | | | | | |
| A | 4,642 | 0.251 | 0.049 | 5.29 | 8.42 | 6,074 | 1,030 | 7,102 | $230 \times 10^{-4}$ | $-280 \times 10^{-4}$ | $50 \times 10^{-4}$ | Loading primarily along wings |
| B | 4,642 | .383 | .049 | 5.29 | 8.42 | 6,074 | 1,030 | 7,102 | 230 | -280 | 50 | Do. |
| C | 4,642 | .184 | .049 | 5.29 | 8.42 | 6,074 | 1,030 | 7,102 | 230 | -280 | 50 | Do. |
| D | 13,291 | .268 | .011 | 15.18 | 24.14 | 19,151 | 1,925 | 20,902 | 270 | -297 | 27 | Do. |
| E | 9,000 | .268 | .011 | 10.29 | 16.36 | 9,590 | 1,520 | 11,120 | 189 | -226 | 37 | Do. |
| Model 5 | | | | | | | | | | | | |
| A | 14,517 | 0.167 | 0.004 | 9.89 | 15.72 | 13,250 | 22,943 | 35,021 | $-144 \times 10^{-4}$ | $-179 \times 10^{-4}$ | $323 \times 10^{-4}$ | Loading primarily along fuselage |
| B | 14,485 | .240 | .003 | 9.87 | 15.68 | 13,338 | 23,618 | 35,994 | -153 | -184 | 337 | Do. |
| C | 14,485 | .163 | .003 | 9.87 | 15.68 | 13,338 | 17,449 | 29,825 | -61 | -184 | 245 | Do. |
| Model 6 | | | | | | | | | | | | |
| A | 6,815 | 0.199 | 0.035 | 16.59 | 23.36 | 3,910 | 2,749 | 6,534 | $76 \times 10^{-4}$ | $-249 \times 10^{-4}$ | $173 \times 10^{-4}$ | Loading primarily along wings |
| B | 6,260 | .178 | .038 | 15.23 | 24.21 | 3,050 | 2,694 | 5,616 | 25 | -208 | 183 | Do. |
| C | 5,820 | .159 | .041 | 14.18 | 22.54 | 2,360 | 2,640 | 4,821 | -22 | -168 | 190 | Loading primarily along fuselage |
| D | 6,815 | .199 | .035 | 16.59 | 23.36 | 2,381 | 3,787 | 6,041 | -92 | -148 | 240 | Do |

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TABLE II.- MASS CHARACTERISTICS OF MODELS TESTED - Concluded

| Loading | Weight (lbs) | Center-of-gravity location | | Relative airplane density, $\mu$ | | Moments of inertia (slug-feet$^2$) | | | Mass parameters | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $x/\bar{c}$ | $z/\bar{c}$ | Sea level | Test altitude | $I_X$ | $I_Y$ | $I_Z$ | $\frac{I_X - I_Y}{mb^2}$ | $\frac{I_Y - I_Z}{mb^2}$ | $\frac{I_Z - I_X}{mb^2}$ | |
| Model 7 | | | | | | | | | | | | |
| A | 11,648 | 0.240 | 0.014 | 13.80 | 21.93 | 3,989 | 27,619 | 29,557 | $-754 \times 10^{-4}$ | $-62 \times 10^{-4}$ | $816 \times 10^{-4}$ | Loading primarily along fuselage |
| B | 11,598 | .241 | .002 | 18.10 | 28.79 | 4,713 | 27,078 | 30,560 | -1192 | -186 | 1378 | Do. |
| Model 8 | | | | | | | | | | | | |
| A | 3,846 | 0.140 | -0.052 | 2.61 | 4.13 | 5,084 | 4,369 | 9,365 | $21 \times 10^{-4}$ | $-144 \times 10^{-4}$ | $123 \times 10^{-4}$ | Loading primarily along wings |
| B | 3,507 | .120 | -.035 | 2.38 | 3.79 | 4,789 | 4,275 | 9,096 | 16 | -152 | 136 | Do. |
| C | 3,890 | .140 | -.052 | 2.65 | 4.20 | 4,060 | 4,369 | 8,340 | -9 | -115 | 124 | Loading primarily along fuselage |
| D | 4,004 | .140 | -.052 | 2.71 | 4.30 | 5,941 | 4,369 | 10,222 | 43 | -161 | 118 | Loading primarily along wings |
| E | 3,846 | .190 | -.052 | 2.61 | 4.13 | 5,084 | 3,844 | 8,840 | 36 | -144 | 108 | Do. |
| F | 3,846 | .090 | -.052 | 2.61 | 4.13 | 5,084 | 4,864 | 9,860 | 6 | -144 | 138 | Do. |
| G | 7,886 | .140 | -.010 | 5.35 | 8.51 | 5,664 | 4,738 | 10,204 | 13 | -77 | 64 | Do. |
| H | 7,547 | .120 | -.023 | 5.11 | 8.13 | 5,384 | 4,655 | 9,930 | 10 | -77 | 67 | Do. |
| I | 7,886 | .090 | -.010 | 5.35 | 8.51 | 5,664 | 5,738 | 11,203 | -1 | -77 | 78 | |
| Model 9 | | | | | | | | | | | | |
| A | 4,615 | 0.225 | 0.006 | 6.05 | 8.19 | 8,090 | 4,915 | 12,780 | $405 \times 10^{-4}$ | $-1006 \times 10^{-4}$ | $601 \times 10^{-4}$ | Loading primarily along wings |
| B | 5,287 | .225 | .006 | 6.92 | 9.36 | 10,193 | 4,915 | 14,883 | 590 | -1115 | 525 | Do. |
| C | 4,615 | .225 | .006 | 6.05 | 8.19 | 4,126 | 5,750 | 9,651 | -208 | -500 | 708 | Loading primarily along fuselage |
| D | 4,615 | .250 | .006 | 6.05 | 8.19 | 4,126 | 5,750 | 9,651 | -208 | -500 | 708 | Do. |
| E | 4,615 | .200 | .006 | 6.05 | 8.19 | 4,126 | 5,750 | 9,651 | -208 | -500 | 708 | Do. |
| F | 6,283 | .225 | .006 | 8.24 | 11.16 | 8,053 | 4,765 | 12,056 | 309 | -686 | 377 | Loading primarily along wings |
| G | 6,947 | .225 | .006 | 9.09 | 12.30 | 10,122 | 4,765 | 14,243 | 456 | -807 | 351 | Do. |
| H | 7,320 | .225 | .006 | 9.58 | 12.96 | 8,053 | 10,578 | 17,527 | -204 | -563 | 767 | Loading primarily along fuselage |
| I | 11,890 | .218 | .017 | 15.59 | 21.11 | 17,178 | 6,900 | 23,571 | 511 | -803 | 281 | Loading primarily along wings |
| Model 10 | | | | | | | | | | | | |
| A | 16,850 | 0.263 | 0.005 | 22.1 | 35.1 | 18,296 | 15,367 | 33,703 | $103 \times 10^{-4}$ | $-646 \times 10^{-4}$ | $543 \times 10^{-4}$ | Loading primarily along wings |
| Model 11 | | | | | | | | | | | | |
| A | 3,241 | 0.120 | 0.182 | 6.07 | 8.22 | 1,409 | 4,062 | 5,041 | $-197 \times 10^{-4}$ | $-72 \times 10^{-4}$ | $269 \times 10^{-4}$ | Loading primarily along fuselage |
| B | 3,241 | .120 | .182 | 6.07 | 8.22 | 1,973 | 4,062 | 5,605 | -155 | -114 | 269 | Do. |
| C | 3,241 | .120 | .182 | 6.07 | 8.22 | 1,409 | 3,453 | 4,432 | -151 | -73 | 224 | Do. |
| D | 3,241 | .120 | .182 | 6.07 | 8.22 | 1,409 | 5,687 | 6,666 | -317 | -72 | 389 | Do. |
| E | 3,241 | .220 | .182 | 6.07 | 8.22 | 1,409 | 4,062 | 5,041 | -197 | -72 | 269 | Do. |
| F | 3,241 | .070 | .182 | 6.07 | 8.22 | 1,409 | 4,062 | 5,041 | -197 | -72 | 269 | Do. |
| G | 3,241 | [a].08 | .182 | 6.07 | 8.22 | 1,409 | 4,062 | 5,041 | -197 | -72 | 269 | Do. |
| H | 3,241 | [a].37 | .182 | 6.07 | 8.22 | 1,409 | 4,062 | 5,041 | -197 | -72 | 269 | Do. |
| Model 12 | | | | | | | | | | | | |
| A | 7,717 | 0.118 | -0.019 | 11.52 | 15.61 | 4,120 | 10,896 | 14,712 | $-168 \times 10^{-4}$ | $-95 \times 10^{-4}$ | $263 \times 10^{-4}$ | Loading primarily along fuselage |
| B | 7,906 | .099 | -.008 | 11.80 | 15.99 | 6,592 | 11,916 | 17,184 | -114 | -116 | 230 | Do. |
| C | 7,851 | .109 | -.008 | 11.72 | 15.88 | 5,657 | 8,717 | 14,270 | -68 | -123 | 191 | Do. |
| D | 7,811 | .048 | -.012 | 11.66 | 15.80 | 5,063 | 12,672 | 17,718 | -186 | -124 | 310 | Do. |
| E | 7,835 | .202 | -.016 | 11.79 | 15.84 | 4,542 | 9,860 | 14,255 | -130 | -107 | 237 | Do. |

[a]Forward of leading edge of M.A.C.

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TABLE III.- MODIFICATIONS TESTED ON MODELS

| Modification | Modification made to — Wing | Wing-tip rudders | Vertical fin | Other part | Effect on spin and recovery characteristics | Modification shown in figure | Data presented in chart |
|---|---|---|---|---|---|---|---|
| Model 1 | | | | | | | |
| A | -------------- | Split rudder | -------------------- | -------------------- | Detrimental | 5(a) | 1 |
| Model 2 | | | | | | | |
| A | -------------- | -------------------- | -------------------- | Equivalent propeller fin area added | Slightly detrimental | 5(b) | 2 |
| B | 20-percent semispan slats | -------------------- | -------------------- | -------------------- | Detrimental | 5(b) | 2 |
| C | 35-percent semispan slats | -------------------- | -------------------- | -------------------- | ----------do---------- | 5(b) | 2 |
| D | -------------- | -------------------- | Horizontal area | -------------------- | Ineffective | 5(b) | 2 |
| Model 4 | | | | | | | |
| A | 40-percent semispan slats | -------------------- | -------------------- | -------------------- | Slightly detrimental | 5(c) | 4 |
| B | 25-percent semispan slats | -------------------- | -------------------- | -------------------- | Ineffective | 5(c) | 4 |
| C | 60-percent semispan slats | -------------------- | -------------------- | -------------------- | Detrimental | 5(c) | 4 |
| D | 25-percent semispan auxiliary airfoil | -------------------- | -------------------- | -------------------- | Slightly detrimental | 5(c) | 4 |
| E | 25-percent semispan slats | -------------------- | Vertical fins removed | -------------------- | Detrimental | 5(c) | 4 |
| F | 25-percent semispan slats | Neutral | Surface made movable aft of 50-percent-chord line | -------------------- | Beneficial | 5(c) | 4 |
| G | 25-percent semispan slats | Neutral | Surface made movable aft of 50-percent-chord line plus area A | -------------------- | Very beneficial | 5(c) | 4 |
| H | 25-percent semispan slats | Neutral; Area B added to trailing edge of wing | Surface made movable aft of 50-percent-chord line | -------------------- | Beneficial | 5(c) | 4 |
| I | 25-percent semispan slats | Area C added, doubling chord of rudders | ------------------ | -------------------- | Somewhat beneficial | 5(c) | 4 |
| J | 25-percent semispan slats | Area C added and hinge line moved to trailing edge of wing | ------------------ | -------------------- | Beneficial | 5(c) | 4 |
| K | 25-percent semispan slats | Area D added and hinge line moved to trailing edge of wing | ------------------ | -------------------- | Very beneficial | 5(c) | 4 |
| L | Area F added | Neutral | Fins moved outboard, area E added, surface made movable aft of 50-percent-chord line | -------------------- | Beneficial | 5(c) | 4 |
| M | -------------- | Neutral | Fins moved outboard; area E added; area G used as rudders | -------------------- | Beneficial | 5(c) | Not presented |
| Model 5 | | | | | | | |
| A | 55.4-percent semispan slats | -------------------- | -------------------- | -------------------- | Slightly detrimental | 1(e) | 5 |
| Model 6 | | | | | | | |
| A | -------------- | -------------------- | Single vertical tail moved rearward 1.7 inches | -------------------- | Ineffective for loading A, beneficial for loading D | 5(d) | 6 |
| B | -------------- | -------------------- | Dual vertical tails added with same tail volume as original single vertical tail | -------------------- | Ineffective for loading A, ineffective for loading D | 5(d) | 6 |
| C | -------------- | -------------------- | Dual vertical tails moved rearward 1.0 inch to have same tail volume as mod. A | -------------------- | Ineffective for loading A, beneficial for loading D | 5(d) | 6 |
| Model 7 | | | | | | | |
| A | Wing fillets added | -------------------- | ------------------ | -------------------- | Detrimental | 1(g) | 7 |
| B | ------------- | -------------------- | Dual vertical tails | -------------------- | Ineffective | 1(g) | 7 |
| C | ------------- | -------------------- | Large dual vertical tails | -------------------- | Beneficial | 5(e) | Not presented |

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TABLE III.- MODIFICATIONS TESTED ON MODELS - Concluded

| Modification | Modification made to: Wing | Wing-tip rudders | Vertical fin | Other part | Effect on spin and recovery characteristics | Modification shown in figure | Data presented in chart |
|---|---|---|---|---|---|---|---|
| | | | | Model 8 | | | |
| A | Spoilers | ------ | ------ | ------ | Slightly beneficial | 5(f) | 8 |
| B | Increase dihedral to 8° | ------ | ------ | ------ | Ineffective | ------ | 8 |
| C | ------ | ------ | Moved rearward | Large horizontal tail added | Beneficial in improving trim condition | 5(f) | Not presented |
| | | | | Model 10 | | | |
| A | ------ | ------ | Ventral fin 1 | ------ | Ineffective | 5(g) | Not presented |
| B | ------ | ------ | Ventral fin 2 | ------ | ------do------ | 5(g) | Do. |
| C | ------ | ------ | Vertical fin 1 | ------ | ------do------ | 5(g) | Do. |
| D | ------ | ------ | Vertical fin 2 | ------ | ------do------ | 5(g) | Do. |
| E | ------ | ------ | Vertical fin 3 | ------ | ------do------ | 5(g) | Do. |
| F | ------ | ------ | Vertical fin 4 | ------ | ------do------ | 5(g) | Do. |
| G | ------ | ------ | Vertical fin 5 | ------ | ------do------ | 5(g) | Do. |
| H | ------ | ------ | Vertical fin 6 | ------ | ------do------ | 5(g) | Do. |
| I | Spoiler 1 | ------ | Vertical fin 2 | ------ | ------do------ | 5(g) | Do. |
| J | Spoiler 2 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| K | Spoiler 3 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| L | Longitudinal fence 1 | ------ | | | ------do------ | 5(g) | Do. |
| M | Longitudinal fences 1 and 2 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| N | Longitudinal fences 1 and 2 | ------ | Vertical fin 5 | ------ | ------do------ | 5(g) | Do. |
| O | Elevon spoilers | ------ | Vertical fin 5 | ------ | ------do------ | 5(g) | Do. |
| P | Slotted elevon; slats 1 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| Q | Slotted elevon; slats 2 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| R | ------ | ------ | Vertical fin 7; dorsal fin 1 | ------ | ------do------ | 5(g) | Do. |
| S | ------ | ------ | Vertical fin 7; dorsal fin 2 | ------ | ------do------ | 5(g) | Do. |
| T | ------ | ------ | ------ | Supplementary tail 1 | Very slightly beneficial | 5(g) | Do. |
| U | Spoiler 5 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| V | Spoiler 6 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| W | Spoiler 7 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| X | Spoiler 7 | ------ | Vertical fin 2 | ------ | ------do------ | 5(g) | Do. |
| Y | ------ | ------ | ------ | Supplementary tail 2 | Beneficial | 5(g) | Do. |
| Z | Spoiler 4 | ------ | ------ | ------ | ------do------ | 5(g) | Do. |
| A' | ------ | ------ | Vertical fin 7; rearward portion movable as rudder | ------ | ------do------ | 5(g) | Do. |
| | | | | Model 11 | | | |
| A | Ailerons drooped 22° | ------ | ------ | ------ | Ineffective | ------ | 11 |
| B | Aileron chord and area double; ailerons drooped 22° | ------ | | ------ | Slightly beneficial in improving trim condition | ------ | 11 |
| C | Fin A | ------ | ------ | ------ | Ineffective | 5(h) | 11 |
| D | Fin B | ------ | ------ | ------ | Slightly beneficial in improving trim condition | 5(h) | 11 |
| E | Spoilers | ------ | ------ | ------ | Ineffective | 5(h) | 11 |
| F | ------ | Fins and rudder moved to wing tip | ------ | ------ | Ineffective | 5(h) | 11 |
| G | ------ | ------ | ------ | Fin C | Ineffective | 5(h) | 11 |
| H | ------ | ------ | ------ | Fin D | Ineffective | 5(h) | 11 |

NACA

CHART 1.- SPIN DATA OBTAINED WITH MODEL 1

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in the clean condition and recoveries were attempted by rapid full rudder reversal; right erect spins]

| | Loading A | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | | | With | | |
| Elevators | U | N | D | U | N (a) | N (a) | D (a) | D (a) | U | N | D (b) |
| α, deg | 36 | No spin | 82 | 39 | --- | No spin | 49 | No spin | 76 | 46 | -- |
| φ, deg | 2D | | 0 | 4D | --- | | 2D | | 0 | 3D | -- |
| Ω, rps | 0.40 | | 0.92 | 0.40 | --- | | 0.54 | | 0.70 | 0.55 | -- |
| V, fps | 220 | | 133 | 224 | 173 | | 191 | | 162 | 205 | -- |
| Turns for recovery | 3/4<br>1 1/4 | | 6 | 1 1/4 | 1 1/4 | | 2 1/2 | | 4 | 2 3/4<br>2 | |

| | Loading B | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | | | With | | |
| Elevators | U | N | D | U (a) | U (a) | N (a) | N (a) | D (c) | U | N | D (b) |
| α, deg | No spin | No spin | 81 | --- | No spin | 64 | No spin | -- | 77 | 38 | -- |
| φ, deg | | | 1D | --- | | 1D | | -- | 2D | 8D | -- |
| Ω, rps | | | 0.89 | 0.41 | | 0.61 | | -- | 0.72 | 0.51 | -- |
| V, fps | | | 136 | 220 | | 165 | | -- | 160 | 202 | -- |
| Turns for recovery | | | 6 | 1 1/4 | | 2 | | -- | 5 | 1 | -- |

| | Loading C | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | | With | | |
| Elevators | U (bc) | N | D | U | N (d) | N (bd) | D | U | N | D (c) |
| α, deg | ---- | No spin | 79 | 50 | 67 | ---- | No spin | 76 | 51 | -- |
| φ, deg | ---- | | 0 | 1D | 1U | ---- | | 0 | 5D | -- |
| Ω, rps | ---- | | 0.76 | 0.35 | 0.56 | ---- | | 0.64 | 0.40 | -- |
| V, fps | ---- | | 140 | 215 | 165 | ---- | | 160 | 198 | -- |
| Turns for recovery | 1 | | 4 1/2 | 1 1/2 | 2 | | | 5 | 1 3/4 | |

| | Loading D | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D (c) |
| α, deg | No spin | No spin | 84 | 54 | No spin | No spin | 80 | 53 | -- |
| φ, deg | | | 1D | 0 | | | 1D | 5D | -- |
| Ω, rps | | | 1.04 | 0.44 | | | 0.79 | 0.57 | -- |
| V, fps | | | 133 | 209 | | | 151 | 182 | -- |
| Turns for recovery | | | ---- | ---- | | | ---- | ---- | -- |

| | Loading E | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D (c) |
| α, deg | 40 | 73 | 83 | 62 | ---- | 73 | 82 | 51 | -- |
| φ, deg | 10D | 0 | 0 | 2D | ---- | 0 | 1D | 8D | -- |
| Ω, rps | 0.54 | 0.72 | 1.00 | 0.57 | ---- | 0.71 | 0.89 | 0.47 | -- |
| V, fps | 231 | 162 | 133 | 202 | 180 | 173 | 162 | 187 | -- |
| Turns for recovery | ---- | 5 1/2 | ---- | 1 1/2 | 3 | >3 3/4 | 5 | ---- | -- |

| | Loading F | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U (b) | N | D | U | N | D | U | N | D (b) |
| α, deg | -- | -- | 83 | 59 | 74 | 67 | 80 | 59 | --- |
| φ, deg | -- | -- | 1D | 3D | 1D | 2D | 2D | 7D | --- |
| Ω, rps | -- | -- | 0.84 | 0.34 | 0.64 | 0.56 | 0.72 | 0.45 | --- |
| V, fps | -- | -- | 122 | 182 | 153 | 162 | 153 | 178 | --- |
| Turns for recovery | -- | -- | --- | 2 1/2 | 3 | --- | --- | --- | --- |

| | Loading G | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Elevators | Against | | | Neutral | | | With | | |
| Elevons as Elevators | U | N | D | U | N | D | U | N | D (c) |
| α, deg | No spin | 65 | 80 | 38 | No spin | No spin | 75 | 49 | -- |
| φ, deg | | 1U | 1D | 1D | | | 1D | 5D | -- |
| Ω, rps | | 0.64 | 0.88 | 0.39 | | | 0.74 | 0.49 | -- |
| V, fps | | 162 | 125 | 215 | | | 155 | 189 | -- |
| Turns for recovery | | ---- | ---- | ---- | | | ---- | ---- | -- |

| | Loading A, flaps down 60° | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Elevators | Against | | | Neutral | | | With | | |
| Elevons as Elevators | U | N | D | U (c) | N | D | U | N | D |
| α, deg | -- | -- | No spin | -- | No spin | No spin | 75 | --- | -- |
| φ, deg | -- | -- | | -- | | | 0 | --- | -- |
| Ω, rps | -- | -- | | -- | | | 0.72 | --- | -- |
| V, fps | -- | -- | | -- | | | 158 | --- | -- |
| Turns for recovery | -- | -- | | -- | | | --- | --- | -- |

| | Loading A, landing gear extended | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Elevators | Against | | | Neutral | | | With | | |
| Elevons as Elevators | U | N | D | U | N | D | U | N | D (b) |
| α, deg | No spin | No spin | 79 | No spin | No spin | No spin | 78 | - | -- |
| φ, deg | | | 0 | | | | 1D | - | -- |
| Ω, rps | | | 0.77 | | | | 0.72 | - | -- |
| V, fps | | | 147 | | | | 158 | - | -- |
| Turns for recovery | | | --- | | | | --- | - | -- |

| | Loading A, landing condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Elevators | Against | | | Neutral | | | With | | |
| Elevons as Elevators | U | N | D | U | N | D | U | N | D (b) |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | 74 | 41 | -- |
| φ, deg | | | | | | | 4D | 6D | -- |
| Ω, rps | | | | | | | 0.62 | 0.48 | -- |
| V, fps | | | | | | | 169 | 205 | -- |
| Turns for recovery | | | | | | | 2 1/2 | 1 1/2 | -- |

| | Loading A - Modification A - right rudder 60°, left rudder 0° | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | | With | | |
| Elevators | U | N | D | U (a) | U (a) | N | D | U | N | D |
| α, deg | No spin | No spin | --- | No spin | 69 | 65 | 71 | 78 | 67 | No spin |
| φ, deg | | | ---- | | 1U | 1D | 0 | 0 | 1D | |
| Ω, rps | | | ---- | | 0.55 | 0.64 | 0.71 | 0.78 | 0.58 | |
| V, fps | | | 136 | | 184 | 162 | 162 | 158 | 162 | |
| Turns for recovery | | | ∞ | | e---- | 3 | 4 | 5 1/2 | e---- | |

| | Loading H | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U (bf) | N (f) | D (f) | U | N (b) | D (b) |
| α, deg | No spin | --- | 81 | 45 | ---- | -- | 81 | -- | -- |
| φ, deg | | ---- | 0 | 6D | ---- | -- | 1D | -- | -- |
| Ω, rps | | --- | 0.56 | 0.24 | ---- | -- | 0.55 | -- | -- |
| V, fps | | 173 | 134 | 200 | ---- | -- | 158 | -- | -- |
| Turns for recovery | | 3<br>5 1/2 | ∞ | --- | >2 1/2 | -- | 5 1/2<br>2 1/2 | -- | -- |

| | Loading H, rudder-neutral spins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D (c) | U | N (c) | D (c) |
| α, deg | No spin | ---- | 67 | No spin | No spin | ---- | 71 | --- | -- |
| φ, deg | | ---- | 1D | | | ---- | 4U | --- | -- |
| Ω, rps | | ---- | 0.47 | | | ---- | 0.43 | --- | -- |
| V, fps | | 218 | 172 | | | ---- | 184 | --- | -- |
| Turns for recovery | | ---- | ---- | | | ---- | ---- | --- | -- |

[a]Two conditions possible.
[b]Model oscillatory in pitch.
[c]Steep spin, high rate of descent.
[d]Two types of spin.
[e]Model went into steep rapid spin after rudder reversal.
[f]Wandering spin.

NACA

CHART 2.- SPIN DATA OBTAINED WITH MODEL 2

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in clean condition and recoveries were attempted by rapid full rudder reversal; right erect spins]

| | Loading A | | | | | | | | | | | | | | | Loading A rudder controls neutral | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against Full | | | | Against 1/2 | Neutral | | | | | With 1/2 | With Full | | | | Against | | | Neutral | | | With | | |
| Elevators | U (a)(b) | U (b) | N | D | N | U (c) | N (b)(c) | N (b)(c) | 1/2D | D | N (c) | U (b)(c) | U (b)(c) | N (c) | D (c) | U | N | D | U | N | D | U (c) | N (c) | D (g)(h) |
| α, deg | -- | -- | No spin | No spin | No spin | 44,37 | 34,21 | 27,20 | No spin | No spin | 33,26 | 38 | 49,41 | 39,32 | 32 | No spin | No spin | No spin | No spin | -- | No spin | 32,22 | 35,25 | -- |
| ϕ, deg | -- | -- | | | | 3U,4D | 2U,1D | 3U,2D | | | 1U,2D | 2U,2D | 1U,2D | 1U,1D | 2U,1D | | | | | -- | | 3U,4D | 3U,2D | -- |
| Ω, rps | -- | 0.21 | | | | 0.21 | 0.37 | 0.38 | | | 0.37 | 0.31 | 0.34 | 0.35 | 0.39 | | | | | -- | | 0.23 | 0.40 | -- |
| V, fps | -- | 213 | | | | 188 | 220 | 204 | | | 201 | 176 | 163 | 179 | 188 | | | | | -- | | 213 | 204 | -- |
| Turns for recovery | | [d]2; [e]1/4, [e]1/2 | | | | 1/2, 1/2; [f]1/4, [f]1/4; [e]1/4, [e]1 | 2; [f]2 1/2 | ∞ | | | ∞ | ∞ | 2 1/2, 2 1/2; [d][f]>3 1/2; [e]∞ | ∞; [f]∞ | ∞; [f]∞ | | | | | | | | | |

| | Loading A rudder controls against the spin | | | | | | | | | | | Loading B | | | | | | | | | | | | Loading C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | | With | | | | Against | | | Neutral | | | | With | | | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N (b) | N (b)(g) | D | U (b) | U (b) | N | D (g) | U (c) | N (i) | D | U | N (c) | D (b) | D (b)(c) | U (b)(c) | U (b)(c) | N (c) | D (c) | | U (c) | N | D | U (c) | N (c) | D | U (c) | N (c) | D (c) |
| α, deg | No spin | No spin | No spin | No spin | No spin | -- | No spin | No spin | ≈30 | 20,31 | - | 41,33 | - | No spin | - | 42,20 | No spin | 53,22 | 56,47 | 60 | 49,36 | 56,32 | | 37,26 | No spin | No spin | 53,39 | 37,15 | No spin | 55,47 | 47,30 | 43,22 |
| ϕ, deg | | | | | | -- | | | -- | 2U,3D | - | 1U,4D | - | | - | 3U,2D | | 7U,3D | 1U,4D | 1U,2D | 1U,1D | 2U,1D | | 3U,1D | | | 2U,3D | 4U,2D | | 3U,2D | 2U,4D | 3U,2D |
| Ω, rps | | | | | | -- | | | -- | -- | - | 0.22 | - | | - | 0.36 | | 0.42 | 0.33 | 0.25 | 0.35 | 0.37 | | 0.24 | | | 0.24 | 0.40 | | 0.35 | 0.38 | 0.43 |
| V, fps | | | | | | -- | | | -- | -- | - | 206 | - | | 188 | 200 | | 188 | 163 | 180 | 173 | 182 | | 216 | | | 179 | 201 | | 163 | 176 | 185 |
| Turns for recovery | | | | | | | | | | | | 1/2,1 | | | 1/4,1/4 | >5 | | >6 | 2,2 1/4 | >3 | ∞ | ∞ | | 3/4; 1 1/2 | | | 1/2,1/4 | >9 | | ∞ | ∞ | >7 |

| | Loading D | | | | | | | | | Loading E | | | | | | | | | Loading F | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | | Neutral | | | With | | | |
| Elevators | U (c) | N | D | U (c) | N (c) | D | U (c) | N (c) | D (c) | U (c) | N | D | U (c) | N | D | U (c) | N (c) | D | U (c) | N (c) | D (b) | D (bc) | U (j) | N (c) | D (c) | U (c) | N (c) | D (c) | |
| α, deg | 44,36 | No spin | No spin | 51,41 | 43,35 | - | 53,45 | 50,38 | 46,37 | 38,23 | No spin | No spin | 41,17 | No spin | No spin | 51,40 | 43,27 | No spin | 34 | 36,27 | No spin | 43,22 | No spin | 46,40 | 45,21 | 63,51 | 56,41 | 49,35 | |
| ϕ, deg | 3U,3D | | | 7U,5D | 2U,1D | - | 1U,3D | 3U,4D | 1U,2D | 7U,1D | | | 7U,1D | | | 4U,0 | 3U,1D | | 3U,8D | 4U,4D | | 7U,1D | | 2U,3D | 3U,1D | 4U,4D | 2U,4D | 0,3D | |
| Ω, rps | 0.20 | | | 0.22 | 0.28 | 0.35 | 0.29 | 0.32 | 0.32 | 0.44 | | | - | | | 0.39 | 0.51 | | 0.13 | 0.15 | | - | | 0.28 | 0.32 | 0.29 | 0.31 | 0.31 | |
| V, fps | 191 | | | 176 | 194 | 201 | 160 | 176 | 188 | 213 | | | 216 | | | 185 | 182 | | 186 | 201 | | 207; 176 | | 185 | 185 | 160 | 166 | 182 | |
| Turns for recovery | 1/2,1/2 | | | 1/4,1/2 | 4 1/2 | 2 | 1 3/4; 2 1/2 | ∞ | ∞ | ∞ | | | >7 | | | ∞ | ∞ | | 1/4 | 1/4,1/4 | | 1/2,1 | | 3/4,1 | 2 1/2; 3 | 2; 2 1/4 | ∞ | ∞ | |

| | Loading G | | | | | | | | | Loading H | | | | | | | | | Loading A - Modification A | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (a) | N (c) | D (c) | U (j) | N (c) | D (c) | U (c) | N (c) | D (c) | U (c) | N | D | U (c) | N (c) | D | U (c) | N (c) | D (c) | U (c) | N | D | U (c) | N (c) | D (c) | U (c) | N (c) | D (c) |
| α, deg | - | 54,40 | 52,43 | No spin | 55,41 | 51,40 | 63,53 | 53,42 | 54,40 | 36,22 | No spin | No spin | 43,33 | 38,16 | No spin | 49,41 | 43,35 | 40,24 | 38,33 | No spin | No spin | 49,30 | 41,23 | 44,15 | 59,48 | 47,38 | 40,30 |
| ϕ, deg | - | 6U,8D | 3U,1D | | 3U,7D | 4U,4D | 7U,6D | 1U,7D | 2U,8D | 3U,1D | | | 2U | 2U | | 1U | 1U,2D | 2U,2D | 2D | | | 12U6D | 1U2D | 8U 7D | 2U,3D | 1D | 1D |
| Ω, rps | - | 0.19 | 0.24 | | 0.23 | 0.26 | 0.26 | 0.27 | 0.27 | 0.33 | | | 0.27 | · | | 0.35 | 0.39 | 0.45 | 0.18 | | | 0.21 | 0.33 | 0.43 | 0.32 | 0.33 | 0.35 |
| V, fps | - | 166 | 166 | | 170 | 166 | 150 | 157 | 163 | 209 | | | 197 | - | | 176 | 195 | 195 | 201 | | | 188 | 201 | 207 | 163 | 176 | 185 |
| Turns for recovery | | 1/4,1/2 | 1/2,1/2 | | 3/4,1 | 3/4,3/4 | 1,1 1/4 | 1,1 1/4 | 1,1 | >5 | | | [d],>4 | | | ∞ | ∞ | ∞ | 1/2,1/2 | | | 1/2 | [d],>6 | 1 1/2,3 | 2 1/4,3 | ∞ | ∞ |

| | Loading A - Modification B | | | | | | | | | Loading A - Modification C | | | | | | | | | Loading A - Modification D | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | Neutral | | | With | | |
| Elevators | U (c) | N (g) | D | U (c) | N (c) | D | U (c) | N (c) | D | U (c) | N (c) | D | U (c) | N (c) | D (c) | U (c) | N (c) | D | U (c) | D | U (c) | N (c) | D | U (c) | N (c) | D (c) |
| α, deg | 36 | | No spin | 48,41 | 34 | No spin | 48 | 55,41 | 35 | 38 | 34 | No spin | 44 | 38 | 47,37 | 49,42 | 48,38 | 38 | 46,23 | No spin | 49,34 | 38,21 | No spin | 42,30 | 49,31 | 40,26 |
| ϕ, deg | 3U,1D | | | 1U | 2U,2D | | 2U,1D | 3U,1D | 1U | 3U,1D | 3U,4D | | 1U,3D | 1U,2D | 3U,2D | 2U,2D | 1U,1D | 2U | 6U,2D | | 4U,2D | 7U,3D | | 5U,2D | 1U | 5U,1D |
| Ω, rps | 0.31 | | | 0.33 | 0.41 | | 0.41 | 0.44 | 0.44 | 0.31 | - | | 0.31 | 0.41 | 0.44 | 0.42 | 0.43 | 0.45 | 0.32 | | 0.22 | 0.43 | | 0.30 | 0.38 | 0.44 |
| V, fps | 184 | | | 161 | 157 | | 151 | 157 | 163 | 174 | 213 | | 164 | 170 | 170 | 146 | 151 | 154 | 220 | | 207 | 207 | | 220 | 192 | 188 |
| Turns for recovery | ∞ | | | 2 1/4; 2 3/4 | [d]>4 | | ∞ | ∞ | ∞ | ∞ | 3 1/2 | | ∞ | ∞ | 2 1/2 | ∞ | ∞ | ∞ | 1 | | 1,1 1/2 | 7 | | 2 1/2,3 | ∞ | ∞ |

[a]Radius of spin too great to permit testing completely.
[b]Two types of spin.
[c]Oscillatory spin; range of values or average value given.
[d]Visual estimate.
[e]Recovery attempted by movement of elevators to down.
[f]Recovery attempted by neutralization of rudder controls.
[g]Oscillatory in pitch.
[h]Wandering spin.
[i]Steep, wandering and oscillatory spin.
[j]Violently oscillatory in pitch. Amplitude of oscillation increased until model pitched inverted and then stopped spinning.

NACA

CHART 3.- SPIN DATA OBTAINED WITH MODEL 3

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in the clean condition and recoveries were attempted by rapid full rudder reversal; right erect spins]

| | Loading A, rudders against spin | | | | | | | | | Loading A, rudder neutral spins | | | | | | | | | Loading A | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (ab) | N | D | U (ab) | N (ac) | D | U (d) | N | D | U | N | D | U | N (g) | D (bd) | U | N | D (bd) | U | N | D | U | N | D | U | N (dg) | D |
| α, deg | --- | No spin | No spin | --- | --- | --- | 36 | 26 | 25 | No spin | No spin | No spin | No spin | --- | --- | 44 | 32 | 28 | No spin | No spin | No spin | No spin | No spin | No spin | 44 | --- | No spin |
| φ, deg | --- | | | --- | --- | --- | 3U | 3U | 5U | | | | | --- | --- | 0 | 0 | 1D | | | | | | | 2D | --- | |
| Ω, rps | --- | | | --- | --- | --- | 0.10 | 0.21 | 0.21 | | | | | --- | --- | 0.18 | 0.21 | 0.24 | | | | | | | 0.20 | --- | |
| V, fps | 377 | | | 366 | --- | 350 | 319 | 350 | 361 | | | | | --- | >350 | 319 | 350 | 383 | | | | | | | 298 | --- | |
| Turns for recovery | --- | | | --- | --- | --- | [e]$\infty$ | [ef]1 | [ef]$\frac{1}{2}$ | | | | | --- | | [h]$\infty$ [e]$\infty$ | [fh]>8 [ef]>8 | [e]$2\frac{1}{2}$ | | | | | | | [h]$\infty$ | --- | |

| | Loading A, slots open, rudders against spin | | | | | | | | | Loading A, slots open | | | | | | | | | Loading B, rudders against spin | | | | | | | | | Loading B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U (a) | N | D | U | N (i) | D (i) | U | N | D | U | N | D | U | N (i) | D | U | N | D | U (a) | N (i) | D | U | N | D | U | N | D | U (a) | N (i) | D | U | N (i) | D (i) |
| α, deg | No spin | No spin | No spin | 29 | No spin | No spin | 44 | 30 | 26 | No spin | No spin | No spin | No spin | No spin | No spin | 57 | --- | No spin | No spin | No spin | No spin | --- | --- | No spin | 38 | 33 | 25 | No spin | No spin | No spin | --- | --- | No spin | 41 | 29 | 25 |
| φ, deg | | | | 11D | | | 4D | 4D | 5D | | | | | | | 1U | --- | | | | | --- | --- | | 5D | 8D | 7D | | | | --- | --- | | 3D | 1U | 1U |
| Ω, rps | | | | 0.11 | | | 0.22 | 0.24 | 0.23 | | | | | | | 0.26 | | | | | | --- | --- | | 0.15 | 0.19 | 0.13 | | | | --- | --- | | 0.22 | 0.15 | 0.24 |
| V, fps | | | | 377 | | | 318 | 329 | 350 | | | | | | | 377 | --- | | | | | --- | --- | | 320 | 350 | 350 | | | | 383 | --- | | 266 | 372 | 378 |
| Turns for recovery | | | | --- | | | --- | --- | --- | | | | | | | $\infty$ | --- | | | | | --- | --- | | --- | --- | --- | | | | [f]>4 | --- | | $\infty$ | [f]$>4\frac{1}{2}$ | [f]>8 |

| | Loading C rudders against spin | | | | | | | | | Loading C | | | | | | | | | Loading D rudders against spin | | | | | | | | | Loading D | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D | U | N | D | U (j) | N | D (j) | U | N | D | U | N | D | U | N | D | U | N | D | U | N (i) | D | U | N | D | U | N | D |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | 47 | 36 | 34 | No spin | No spin | No spin | 53 | 34 | 25 | 64 | 49 | 35 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | 56 | No spin | 71 | 66 | No spin | 74 | 73 | 60 |
| φ, deg | | | | | | | 6D | 8D | 7D | | | | 1D | 1D | 1U | 1U | 1D | 2D | | | | | | | | | | | 3D | | 2D | 0 | | 1D | .1D | 1D |
| Ω, rps | | | | | | | 0.13 | 0.12 | 0.15 | | | | 0.13 | 0.12 | 0.18 | 0.23 | 0.18 | 0.15 | | | | | | | | | | | 0.17 | | 0.21 | 0.19 | | 0.23 | 0.21 | 0.19 |
| V, fps | | | | | | | 298 | 320 | 320 | | | | 288 | 329 | 298 | 253 | 282 | 329 | | | | | | | | | | | 255 | | 234 | 249 | | 239 | 234 | 244 |
| Turns for recovery | | | | | | | --- | --- | --- | | | | 1 1 | $2\frac{1}{2}$ 4 | $7\frac{1}{2}$ | $\infty$ | $\infty$ | $\infty$ | | | | | | | | | | | [f]1 [f]3 | | 2 | $2\frac{1}{4}$ 3 | | 4 4 | 3 3 | 1 3/4 2 |

| | Loading E rudders against spin | | | | | | | | | Loading E | | | | | | | | | Loading A, pitch flap deflected down 15°, rudders against spin | | | | | | | | | Loading A, pitch flap deflected down 15° | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (g) | N | D | U (g) | N | D | U (g) | N | D | U | N | D | U (g) | N | D | U (g) | N | D | U | N | D | U | N | D | U (d) | N | D | U | N | D | U | N | D | U | N (d) | D |
| α, deg | --- | No spin | No spin | --- | No spin | No spin | --- | No spin | No spin | No spin | No spin | No spin | --- | No spin | No spin | --- | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | --- | 25 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | 57 | 28 | No spin |
| φ, deg | --- | | | --- | | | --- | | | | | | --- | | | --- | | | | | | | | | --- | 4D | | | | | | | | 1U | 1U | |
| Ω, rps | --- | | | --- | | | --- | | | | | | --- | | | --- | | | | | | | | | --- | 0.26 | | | | | | | | 0.25 | --- | |
| V, fps | --- | | | --- | | | --- | | | | | | --- | | | --- | | | | | | | | | --- | 360 | | | | | | | | 255 | --- | |
| Turns for recovery | --- | | | --- | | | --- | | | | | | --- | | | --- | | | | | | | | | --- | --- | | | | | | | | $\infty$ | [f]>8 | |

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[a]Large radius oscillatory spin, average values given.
[b]Wandering spin
[c]Steep wandering spin.
[d]Oscillatory in pitch.
[e]Recovery attempted by moving rudder to full with the spin.
[f]Visual observation.
[g]Steep spin.
[h]Recovery attempted by moving rudder to full against the spin.
[i]Oscillatory spin.
[j]Occasionally oscillated out of spin.

UNCLASSIFIED

[redacted]

CHART 3.- SPIN DATA OBTAINED WITH MODEL 3-CONCLUDED

| | Loading A, landing condition, rudders against spin | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N (i) | D (i) | U | N (i) | D (i) | U | N | D |
| α, deg | 27 | --- | 35 | 31 | 22 | 26 | 47 | 28 | 33 |
| ϕ, deg | 8D | --- | 6D | 4D | 6D | 4D | 3D | 4D | 2D |
| Ω, rps | 0.13 | --- | 0.16 | 0.15 | 0.17 | 0.18 | 0.21 | 0.20 | 0.21 |
| V, fps | 350 | 383 | 340 | 320 | 360 | 308 | 276 | 320 | 329 |
| Turns for recovery | ---- | --- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| | Loading A, landing condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U (i) | N | D |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | -- | No spin | No spin |
| ϕ, deg | | | | | | | -- | | |
| Ω, rps | | | | | | | -- | | |
| V, fps | | | | | | | -- | | |
| Turns for recovery | | | | | | | -- | | |

| | Loading A, landing condition, slots closed, rudders against spin | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N (i) | D | U | N | D | U | N | D |
| α, deg | 26 | --- | 33 | 30 | 29 | 29 | 40 | 35 | 30 |
| ϕ, deg | 3U | --- | 2U | 3U | 3U | 2U | 2U | 4U | 4U |
| Ω, rps | 0.14 | --- | 0.19 | 0.16 | 0.20 | 0.21 | 0.20 | 0.21 | 0.22 |
| V, fps | 319 | --- | 324 | 303 | 319 | 319 | 276 | 298 | 308 |
| Turns for recovery | ---- | --- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| | Loading A, landing condition, slots closed | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | With | | |
| Elevators | U (k) | N | D | U | N | D | U | N (i) | D (a) |
| α, deg | ---- | No spin | No spin | No spin | No spin | No spin | 30 | ---- | ---- |
| ϕ, deg | ---- | | | | | | 1U | ---- | ---- |
| Ω, rps | ---- | | | | | | 0.15 | ---- | ---- |
| V, fps | ---- | | | | | | 340 | 340 | ---- |
| Turns for recovery | ---- | | | | | | ∞ | ∞ | ---- |

[a]Large radius oscillatory spin, average values given.

[i]Oscillatory spin.

[k]Increasing radius – may not spin.

CHART 4.- SPIN DATA OBTAINED WITH MODEL 4

[Unless otherwise indicated, the steady-spin data are for rudder-with spins of the model in the clean condition with split trailing-edge rudders installed and revised elevon deflections and recoveries were attempted by rapid full rudder reversal, right erect spins.]

| | Loading A, circular-arc type rudders installed, original elevon deflections | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | | | | Neutral | | | | | | | | |
| Ailerons | Against | | | | Neutral | | | With | | | | | Against | | | Neutral | | | With | | |
| | Full | | | 1/2 | | | | 1/2 | Full | | | | | | | | | | | | |
| Elevators | U | N | D | 1/2 U | U (a) | N | D | 1/2 U | U | 1/2 U | N (b) | D | U | N | D | U | N | D | U (b) | N | D |
| α, deg | No spin | No spin | No spin | No spin | | No spin | No spin | 37 | 34 | 33 | 34 | No spin | No spin | No spin | No spin | Steep spin | No spin | No spin | 25 | No spin | No spin |
| φ, deg | | | | | | | | 1U | 2U | 1U | 2U | | | | | | | | 0 | | |
| Ω, rps | | | | | | | | | | 0.67 | | | | | | | | | 0.69 | | |
| V, fps | | | | | >190 | | | 196 | 182 | 194 | 180 | | | | | | | | 214 | | |
| Turns for recovery | $c_{4\frac{1}{2}}$ | $c_{3\frac{1}{2}}$ | $cd_{4\frac{1}{2}}$ | $c_{7\frac{1}{2}}$ | | $c_7$ | $cd_4$ | | ∞ | | | $cd_4$ | $c_7$ | $c_5$ | $cd_4$ | | $c_5$ | $cd_4$ | | $c_{10}$ | $cd_8$ |

| | Loading A, circular-arc type rudders installed, original elevon deflections | | | | | | | | | Loading A, circular-arc type rudders installed, original elevon deflections, modification A | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | Against | | | | | | | | | With | | | | | | | | | Against | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Neutral | | With | | |
| Elevators | U | N | D | U (a) | N | D | U (b) | N | D | U | N | D | U | N | D | U (e) | N | D | U (a) | N | U (e) | N | D |
| α, deg | No spin | No spin | No spin | | No spin | No spin | 30 | No spin | No spin | No spin | No spin | No spin | 42 | 45 | No spin | 51 | 46 | No spin | | No spin | 33 | No spin | No spin |
| φ, deg | | | | | | | 1D | | | | | | 2U | 1U | | 0 | 0 | | | | 1D | | |
| Ω, rps | | | | | | | 0.74 | | | | | | 0.63 | 0.62 | | 0.64 | 0.61 | | | | 0.62 | | |
| V, fps | | | | >249 | | | 208 | | | | | | 171 | 166 | | 158 | 160 | | 231 | | 196 | | |
| Turns for recovery | $c_4$ | $c_3$ | $cd_{3\frac{1}{2}}$ | | $c_5$ | $cd_5$ | | $c_{12}$ | $cd_{4\frac{1}{2}}$ | $c_{10}$ | $c_{12}$ | $cd_{15}$ | >6 | $1\frac{1}{2}$ - $1\frac{3}{4}$ | $cd_{11}$ | $9\frac{1}{2}$ | $\frac{3}{3}$ | $cd_{14}$ | | $c_7$ | | $c_6$ | $cd_6$ |

| | Loading A | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | Against | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D | U (b) | N | D | U (b) | N | D | U (b) | N | D |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | 20 | No spin | No spin | 26 | No spin | No spin | 31 | No spin | No spin |
| φ, deg | | | | | | | | | | 3D | | | 3D | | | 2D | | |
| Ω, rps | | | | | | | | | | 0.53 | | | 0.45 | | | 0.51 | | |
| V, fps | | | | | | | | | | 208 | | | 199 | | | 199 | | |
| Turns for recovery | $c_{5\frac{1}{2}}$ | $c_7$ | $cd_{11}$ | $c_8$ | $c_{10}$ | $cd_7$ | $c_{18}$ | $c_{11}$ | $cd_6$ | | $c_8$ | $cd_6$ | | $c_7$ | $cd_5$ | | $c_{16}$ | $cd_8$ |

| | Loading A, modification B | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | Against | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D | U | N | D | U | N | D | U | N | D |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | 60 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | 29 | No spin | No spin |
| φ, deg | | | | | | | 1U | | | | | | | | | 2D | | |
| Ω, rps | | | | | | | 0.56 | | | | | | | | | 0.52 | | |
| V, fps | | | | | | | 163 | | | | | | | | | 182 | | |
| Turns for recovery | $c_{11}$ | $c_{11}$ | $cd_8$ | $c_{10}$ | $c_{7\frac{1}{2}}$ | $cd_7$ | >7 | $c_{13}$ | $cd_{10}$ | $c_9$ | $c_5$ | $cd_4$ | $c_7$ | $c_8$ | $cd_{4\frac{1}{2}}$ | | $c_{10}$ | $cd_6$ |

[a]Large radius spin; model may eventually recover.
[b]Wandering spin; slightly oscillatory in pitch.
[c]Number of turns required for model to stop spinning after being launched with initial spin rotation.
[d]After recovery, model goes inverted.
[e]Oscillatory in pitch.

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CHART 4.- SPIN DATA OBTAINED WITH MODEL 4-CONTINUED

Loading A, modification C

| Rudder | With | | | | | | | | | Against | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U (f) | N | D | U (f) | N (f) | D | U (eg) | N | D | U (eg) | N (eg) | D | U (eg) | N (eg) | D |
| α, deg | No spin | No spin | No spin | 33 | No spin | No spin | 37 | 45 | No spin | 36 | No spin | No spin | 36 | No spin | No spin | 39 | 39 | No spin |
| ϕ, deg | | | | 2U | | | 2U | 2U | | 1D | | | 3D | | | 2D | 1D | |
| Ω, rps | | | | 0.43 | | | 0.46 | 0.42 | | 0.62 | | | 0.50 | | | 0.52 | 0.65 | |
| V, fps | | | | 188 | | | 180 | 158 | | 180 | | | 176 | | | 180 | 163 | |
| Turns for recovery | [c]9 | [c]7 | [c,d]6 | ∞ | [c]12 | [c,d]12 | ∞ | ∞ | [c,d]7 | | [c]8 | [c,d]6 | | [c]7 | [c,d]6 | | | [c,d]8 |

Loading A, modification D

| Rudder | With | | | | | | | | | Against | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U (eg) | N | D | U | N | D | U | N | D | U | N (eg) | D |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | 35<br>50 | No spin | No spin | Steep spin | No spin | No spin | Steep spin | No spin | No spin | Steep spin | 28 | No spin |
| ϕ, deg | | | | | | | 2U | | | | | | | | | | 1D | |
| Ω, rps | | | | | | | 0.53 | | | | | | | | | | 0.70 | |
| V, fps | | | | | | | 176 | | | | | | | | | | 260 | |
| Turns for recovery | [c]12 | [c]18 | [c,d]18 | [c]15 | [c]7 | [c,d]15 | ∞ | [c]15 | [c,d]10 | | [c]7 | [c,d]10 | | [c]8 | [c,d]10 | | | [c,d]12 |

| | Loading B, circular-arc type rudders installed, original elevon deflections | | | | | | | | | Loading C, circular-arc type rudders installed, original elevon deflections | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | With | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (hi) | N | D | U (i) | N | D | U (i) | N (i) | D (i) | U | N | D | U | N | D | U | N | D |
| α, deg | 38 | No spin | No spin | 47 | 43 | No spin | 52 | 47 | 39 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin |
| ϕ, deg | 8U<br>7D | | | 9U<br>6D | 0 | | 3U<br>5D | 5U<br>6D | 3U<br>4D | | | | | | | | | |
| Ω, rps | 0.23 | | | 0.41 | 0.45 | | 0.45 | 0.46 | 0.45 | | | | | | | | | |
| V, fps | 197 | | | 185 | 185 | | 177 | 174 | 191 | | | | | | | | | |
| Turns for recovery | [j]$\frac{1}{4}$ [j]$\frac{1}{4}$ | [c]15 | [c]17 | $1\frac{1}{4}$ $1\frac{1}{4}$ | >6 | [c]11 | >10 | >9 | ∞ | [c]4 | [c]$4\frac{1}{2}$ | [c]5 | [c]8 | [c]7 | [c,d]4 | [c]30 | [c]5 | [c,d]4 |

Loading A, modification E

| Rudder | With | | | | | | | | Against | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | U (g) | N | D | U | N (g) | D (k) | U | N | D | U (eg) | N | D | U (e) | N (e) | D |
| α, deg | No spin | No spin | 68 | No spin | No spin | 50 | 59 | 70 | Steep spin | No spin | No spin | 35 | No spin | No spin | 46 | 35 | No spin |
| ϕ, deg | | | 1U | | | 2U | 1U | 1U | | | | 3D | | | 1U | 3D | |
| Ω, rps | | | 0.76 | | | 0.53 | 0.76 | 0.86 | | | | 0.67 | | | 0.63 | 0.69 | |
| V, fps | | | 155 | | | 176 | 126 | 123 | | | | 202 | | | 185 | 185 | |
| Turns for recovery | [c]20 | [c]30 | ∞ | [c]22 | [c]15 | ∞ | ∞ | [d]7<br>[d]8 | | [c]13 | [c]12 | | [c]13 | [c]10 | | | [c,d]10 |

[c]Number of turns required for model to stop spinning after being launched with initial spin rotation.
[d]After recovery, model goes inverted.
[e]Oscillatory in pitch.
[f]Wandering and oscillatory in pitch.
[g]Wandering spin.
[h]Large radius spin, model may eventually recover.
[i]Wandering spin; slightly oscillatory in pitch and roll; range of values given.
[j]Visual estimate.
[k]Oscillatory in roll.

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CHART 4.- SPIN DATA OBTAINED WITH MODEL 4—CONTINUED

| | Loading D, modification B | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | Against | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (l) | N (lm) | D (lm) | U (l) | N (lm) | D (lm) | U (l) | N (lm) | D (lm) | U | N | D | U | N | D | U (p) | N (p) | D |
| α, deg | 73 | 56<br>95 | 66<br>90 | 75 | 69<br>83 | 58<br>78 | 58 | 60<br>76 | 56<br>81 | No spin | Steep spin | No spin | Steep spin | Steep spin | Steep spin | | | Steep spin |
| ϕ, deg | 1U | 11U<br>11D | 5U<br>4D | 0 | 0 | 6U<br>6D | 2U | 0 | 7U<br>5D | | | | | | | | | |
| Ω, rps | 0.91 | 1.16 | 1.14 | 0.96 | 0.98 | 0.92 | 0.71 | 0.95 | 0.91 | | | | | | | | | |
| V, fps | 246 | 231 | 231 | 246 | 231 | 234 | 263 | 252 | 240 | | | | | | | 297 | 278 | |
| Turns for recovery | | 8<br>> 10 | 8<br>14 | >13<br>[n] ∞<br>[o] >8 | >15 | 6<br>11 | >15 | >7 | >6 | [c]14 | [q]16 | [c]13 | [q]16 | [q]12 | | * | | [q]17 |

| | Loading D, modification D | | | | | | | | | | | | | Loading D, modification F | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | Against | | | | 30° With | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | Neu-tral | With | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D | U | N | U | U | U | N | D | U (p) | N | D | U (p) | N | D |
| α, deg | No spin | No spin | No spin | Steep spin | Steep spin | No spin | Steep spin | Steep spin | No spin | Steep spin | Steep spin | Steep spin | Steep spin | No spin | No spin | No spin | | Steep spin | No spin | | | Steep spin |
| ϕ, deg | | | | | | | | | | | | | | | | | | | | | | |
| Ω, rps | | | | | | | | | | | | | | | | | | | | | | |
| V, fps | | | | | | | | | | | | | | | | | 328 | | | 272 | 341 | |
| Turns for recovery | [c]23 | [c]25 | [c]30 | [q]27 | [q]30 | [c]20 | | [q]20 | [c]23 | [q]30 | [q]30 | [q]26 | [q]30 | [c]18 | [c]18 | [dk]15 | | [q]15 | [dk]20 | $>6\frac{1}{2}$ | | [q]15 |

| | Loading D, modification F | | | | | | | | | Loading D, modification G | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | Against | | | | | | | | | 30° With | | | | | | | | | 30° Against | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D | U | N | D | U | N | D | U (p) | N | D | U | N | D | U | N | D | U (p) | N | D |
| α, deg | No spin | No spin | No spin | Steep spin | Steep spin | No spin | Steep spin | Steep spin | No spin | No spin | No spin | No spin | Steep spin | No spin | No spin | | | Steep spin | No spin | No spin | No spin | Steep spin | Steep spin | No spin | | Steep spin | No spin |
| ϕ, deg | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ω, rps | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| V, fps | | | | | | | | | | | | | | | | 354 | 309 | | | | | | | | 341 | | |
| Turns for recovery | [c]14 | [c]15 | [dk]10 | [q]13 | [q]12 | [cd]10 | [q]15 | [q]15 | [cd]12 | [c]11 | [c]8 | [cd]12 | [q]15<br>[d]or<br>1 1/4<br>[d]or<br>2 1/2 | [c]10 | [cd]15 | | | [q]19 | [c]9 | [c]8 | [cd]8 | | [q]12 | [cd]12 | | [q]15 | [cd]8 |

| | Loading D, modification H | | | | | | | | | | | | | | | | | | Loading D, modification I | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | | | | | | Against | | | | | | | | | With | | | | | Against | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Neutral | | With | | | Neu-tral | With | | |
| Elevators | U | N | D | U | N | D | U (p) | N | D | U | N | D | U | N | D | U (p) | N (p) | D | U | N | U | N | D | U | U (s) | N | D |
| α, deg | No spin | No spin | No spin | Steep spin | Steep spin | No spin | | Steep spin | Steep spin | No spin | No spin | No spin | Steep spin | Steep spin | No spin | 40 | | Steep spin | No spin | No spin | Steep spin | No spin | No spin | Steep spin | | Steep spin | No spin |
| ϕ, deg | | | | | | | | | | | | | | | | 0 | | | | | | | | | | | |
| Ω, rps | | | | | | | | | | | | | | | | 0.69 | | | | | | | | | | | |
| V, fps | | | | | | | 288 | | | | | | | | | 306 | App. 335 | | | | | | | | 385 | | |
| Turns for recovery | [c]14 | [c]12 | [c]17 | [q]15 | [q]20 | [c]20 | | | [q]15 | [c]14 | [c]10 · | [c]10 | | [q]14 | [c]8 | | | [q]18 | [c]20 | [c]18 | | [c]25 | [c]30 | [q]14 | | | [c]8 |

[c]Number of turns required for model to stop spinning after being launched with initial spin rotation.

[d]After recovery, model goes inverted.

[l]Flat and wandering spin.

[m]Oscillatory spin; range of values given.

[n]Recovery attempted by elevon reversal, stick moved from full back to full left and forward.

[o]Recovery attempted by simultaneous rudder and elevon reversal; stick moved from full back to full left and forward.

[p]Steep, wandering spin.

[q]Number of turns before model strikes safety net.

[r]Recovery attempted before model reached final steep attitude.

[s]Steep spin.

CHART 4.- SPIN DATA OBTAINED WITH MODEL 4-CONCLUDED

| | Loading D, modification J | | | | | | | | | Loading D, modification K | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | With | | | | Against | | | | | With | | | | | Against | | | | |
| Ailerons | Neutral | With | | | Neutral | | With | | | Neutral | | With | | | Neutral | | | With | |
| Elevators | U | U | N | D | U (s) | N | U (s) | N | D | N | D | U | N | D | U (m) | N | D | U | D |
| α, deg | No spin | | No spin | No spin | | No spin | | Steep spin | No spin | No spin | No spin | No spin | No spin | No spin | | No spin | No spin | Steep spin | No spin |
| φ, deg | | | | | | | | | | | | | | | | | | | |
| Ω, rps | | | | | | | | | | | | | | | | | | | |
| V, fps | | 249 | | | 315 | | 315 | | | | | | | | 297 | | | | |
| Turns for recovery | [c]30 | | [c]30 | [cd]20 | | [cd]15 | | | [cd]12 | [c]12 | [cd]10 | [c]20 | [c]20 | [cd]10 | | [c]14 | [cd]10 | | [cd]10 |

| | Loading D, wing-tip rudders neutral, modification L | | | | | | | | | | | | | | Loading D, landing condition, modification B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | 30° With | | | | | | | 30° Against | | | | | | | With | | | | | | | | |
| Ailerons | Against | | Neutral | | | With | | Against | | Neutral | | | With | | Against | | | Neutral | | | With | | |
| Elevators | N | D | U (t) | N | D | N (e) | D (t) | N | D | U (t) | N (t) | D | N (e) | D (t) | U | N | D | U | N | D | U (g) | N (eg) | D |
| α, deg | No spin | No spin | Steep spin | Steep spin | No spin | 37,66 | Steep spin | No spin | No spin | Steep spin | Steep spin | No spin | 39 | Steep spin | Steep spin | 74 | 74 | Steep spin | 59 | No spin | 58 | 60 | No spin |
| φ, deg | | | | | | 1U | | | | | | | 1U | | | 1U | 1D | | 1D | | 2D | 1D | |
| Ω, rps | | | | | | 0.61 | | | | | | | 0.65 | | | 1.08 | 1.05 | | 0.74 | | 0.68 | 0.79 | |
| V, fps | | | | | | 282 | | | | | | | 348 | | | 234 | 234 | | 240 | | 263 | 252 | |
| Turns for recovery | [c]18 | [c]19 | [q]21 | [q]24 | [cq]26 | | [q]26 | [c]13 | [cq]15 | [q]18 | [q]19 | [cd]16 | | [q]20 | [q]30 | | | [q]40 | | [dq]70 | | | [cd]38 |

| | Loading D, landing condition, modification B | | | | | | | | | Loading E, modification B | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rudder | Against | | | | | | | | | With | | | | | | | | Against | | | | | | | | |
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U (g) | N (eg) | D | U | N | D | U | N | D | U | D (e) | U | N | D | U | N | D | U (ep) | N (p) | D (p) |
| α, deg | No spin | No spin | No spin | Steep spin | Steep spin | No spin | | | Steep spin | No spin | No spin | No spin | No spin | No spin | No spin | 62 | 45,75 | No spin | No spin | No spin | No spin | No spin | No spin | 22,45 | | |
| φ, deg | | | | | | | | | | | | | | | | 2U | 11D7U | | | | | | | 2D | | |
| Ω, rps | | | | | | | | | | | | | | | | 0.76 | 0.79 | | | | | | | 0.60 | | |
| V, fps | | | | | | | 341 | 351 | | | | | | | | 202 | 208 | | | | | | | 254 | 263 | 247 |
| Turns for recovery | [c]24 | [c]14 | [cd]12 | [q]27 | [q]24 | [dq]20 | | | [q]21 | [c]16 | [c]34 | [cd]28 | [c]18 | [c]14 | [cd]53 | [n]>23/4 [o]2 3/4 [o]3, [n]8 | | [c]11 | [c]10 | [cd]12 | [c]32 | [c]10 | [cd]12 | | | |

[c]Number of turns required for model to stop spinning after being launched with initial spin rotation.
[d]After recovery, model goes inverted.
[e]Oscillatory in pitch.
[g]Wandering spin.
[m]Oscillatory spin; range of values given.
[n]Recovery attempted by elevon reversal, stick moved from full back to full left and forward.
[o]Recovery attempted by simultaneous rudder and elevon reversal; stick moved from full back to full left and forward.
[p]Steep, wandering spin.
[q]Number of turns before model strikes safety net.
[s]Steep spin.
[t]After launching, spin progressively steepens.

CHART 5.- SPIN DATA OBTAINED WITH MODEL 5

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in clean condition and recoveries were attempted by rapid full rudder reversal; right erect spins]

| | Loading A | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | Neutral | | | | With | | | |
| | Full | | | 1/3 | | | | | | 1/3 | Full | | |
| Elevators | U (a)(b) | N (c)(d) | D (c) | $\frac{2}{3}$ U (e) | $\frac{2}{3}$ U (e) | U (a)(b) | N (c) | D (c)(e) | D (a)(e) | $\frac{2}{3}$ U (a) | U (c)(d) | N (a) | D (a) |
| α, deg | ---- | 56<br>71 | 54<br>63 | 41<br>51 | ---- | ---- | 41<br>47 | 39<br>45 | ---- | ---- | 43<br>58 | ---- | ---- |
| ϕ, deg | ---- | 7D<br>12U | 5D<br>9U | 2U<br>8U | ---- | ---- | 1D<br>8U | 1D<br>5U | ---- | ---- | 16D<br>19U | ---- | ---- |
| Ω, rps | ---- | 0.37 | 0.36 | 0.28 | ---- | ---- | 0.32 | 0.38 | ---- | ---- | --- | ---- | ---- |
| V, fps | >290 | 194 | 191 | 256 | >312 | >294 | 232 | 230 | >312 | >334 | 250 | >326 | >326 |
| Turns for recovery | $^{f}\frac{1}{4}$<br>$^{f}\frac{1}{2}$ | ∞ | ∞ | $^{g}1\frac{1}{4}$<br>$^{g}1\frac{1}{2}$ | $^{fg}\frac{1}{2}$ | $^{f}\frac{3}{4}$<br>$^{f}1$ | $1\frac{3}{4}$ | $1\frac{3}{4}$<br>$2\frac{1}{2}$ | ---- | $^{fg}\frac{3}{4}$ | 1<br>$1\frac{1}{2}$ | ---- | ---- |

| | Loading A with wing slats extended | | | | | | |
|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | Neutral | With | |
| | Full | | | 1/3 | | | |
| Elevators | U (e) | U (e) | N | $\frac{2}{3}$ U | U | U (c)(h) | N (a) |
| α, deg | 53<br>58 | No spin | 68<br>76 | 50<br>55 | 44<br>54 | ---- | ---- |
| ϕ, deg | 3D<br>1U | | 4D<br>0 | 1D<br>7D | 17D<br>6U | ---- | ---- |
| Ω, rps | 0.32 | | 0.39 | 0.32 | 0.31 | ---- | ---- |
| V, fps | 209 | | 191 | 214 | 232 | ---- | > 312 |
| Turns for recovery | , $1\frac{1}{4}$<br>$2\frac{3}{4}$ | | ∞ | $^{g}1\frac{3}{4}$<br>$^{g}2\frac{1}{4}$ | $1\frac{1}{2}$<br>$1\frac{3}{4}$ | $1\frac{1}{4}$<br>$1\frac{1}{2}$ | $^{f}\frac{3}{4}$ |

| | Loading B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | | With | |
| | Full | | 1/3 | | | | | | |
| Elevators | U | N (c)(h) | $\frac{2}{3}$ U | U | N | D (e) | D (e) | U (c)(h) | N |
| α, deg | ---- | 68<br>86 | ---- | ---- | 41<br>49 | --- | ---- | ---- | ---- |
| ϕ, deg | ---- | 1D<br>3U | ---- | ---- | 2D<br>5U | --- | ---- | ---- | ---- |
| Ω, rps | ---- | 0.35 | ---- | ---- | 0.27 | --- | ---- | 0.21 | ---- |
| V, fps | > 312 | 186 | > 300 | > 300 | 238 | 274 | > 312 | 244 | > 362 |
| Turns for recovery | $^{f}\frac{1}{4}$<br>$^{f}\frac{1}{4}$ | ∞ | $^{g}\frac{1}{4}$<br>$^{g}\frac{1}{2}$ | $^{f}\frac{1}{4}$<br>$^{f}\frac{1}{4}$ | 1<br>$1\frac{1}{4}$ | 2<br>2 | ---- | $\frac{1}{4}$<br>$\frac{1}{2}$ | ---- |

| | Loading C | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | |
| | Full | | 1/3 | | | | | |
| Elevators | U | N | $\frac{2}{3}$ U | U | N (e) | N (e) | U (c) | N |
| α, deg | ---- | 50<br>55 | ---- | ---- | 40<br>49 | ---- | 39<br>49 | ---- |
| ϕ, deg | ---- | 0<br>6U | ---- | ---- | 2U<br>10U | ---- | 10D<br>10U | ---- |
| Ω, rps | ---- | 0.40 | ---- | ---- | 0.40 | ---- | ---- | ---- |
| V, fps | > 326 | 214 | > 300 | > 332 | 262 | > 332 | 256 | > 332 |
| Turns for recovery | $^{f}\frac{1}{4}$<br>$^{f}\frac{1}{2}$ | $2\frac{3}{4}$<br>$3\frac{1}{4}$ | $^{fg}\frac{1}{4}$<br>$^{fg}\frac{1}{4}$ | $^{f}\frac{1}{4}$<br>$^{f}\frac{1}{4}$ | $1\frac{3}{4}$<br>$1\frac{3}{4}$ | $^{fi}\frac{1}{4}$<br>$^{fi}\frac{1}{2}$ | $\frac{3}{4}$<br>$1\frac{1}{4}$ | ---- |

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[a]Steep spin.
[b]Large radius spin.
[c]Wandering spin.
[d]Model oscillatory in roll and pitch.
[e]Two conditions possible.
[f]Recovery attempted before model reached final steeper attitude.
[g]Recovery attempted by reversing rudder to only 2/3 against the spin.
[h]Oscillatory spin.
[i]Visual estimate.

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CHART 6.- SPIN DATA OBTAINED WITH MODEL 6

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in clean condition and recoveries were attempted by rapid full rudder reversal; right erect spins.]

**Loading A**

| Ailerons | Against | | | | Neutral | | | With 1/3 | With Full | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevators | U | N | D (a) | D (a) | U | N | D | U (d) | U | N | D |
| α, deg | No spin | No spin | No spin | 40 | No spin | No spin | No spin | 35, 46 | 54 | 21 | 20 |
| ϕ, deg | | | | 5D | | | | 1D | 2D | 19D | 18D |
| Ω, rps | | | | 0.48 | | | | 0.35 | 0.41 | 0.57 | 0.61 |
| V, fps | | | | 265 | | | | 277 | 239 | 343 | 337 |
| Turns for recovery | | | | 2 1/2<br>>8 1/2<br>∞<br>[bc]1 1/2<br>[bc]2 1/4 | | | | > 4<br>5<br>∞<br>[e]1/2<br>[e]1/2 | ∞<br>[f]∞<br>[f]2 1/2<br>[f]2 3/4<br>[g]3 1/2<br>[g]2 1/2<br>[g]1 1/2<br>[g]3 1/2<br>[h]2 1/2<br>[h]3 1/4<br>[i]1 1/2<br>[i]1<br>[i]1 1/2 | ∞<br>∞<br>[bc]1 1/4<br>[bc]1 1/2 | ∞<br>∞<br>[bc]1 1/2<br>[bc]1 1/2 |

**Loading B**

| Ailerons | Against | | | Neutral | | | With 1/3 | With Full | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevators | U | N | D | U | N | D | U | U | N | D |
| α, deg | No spin | No spin | 57 | No spin | No spin | No spin | 42 | 49 | 21 | 12, 25 |
| ϕ, deg | | | 1U | | | | 0 | 3D | 17D,30D | 8D,23D |
| Ω, rps | | | 0.47 | | | | 0.38 | 0.42 | 0.69 | 0.78 |
| V, fps | | | 221 | | | | 255 | 224 | 343 | 337 |
| Turns for recovery | | | ∞<br>∞ | | | | [i]2 1/2<br>[i]3<br>[i]3 1/2<br>[h]3/4<br>[h]1/2 | ∞<br>9 1/2<br>[h]4 1/2<br>[h]3 | ∞<br>[k]1 1/2<br>[b]1/2<br>[b]1<br>[b]1 1/2 | [c]1 1/2<br>1 3/4 |

**Loading C**

| Ailerons | Against Full | | | Against 1/3 | Neutral | | | | With 1/3 | With 1/3 | With Full | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevators | U | N | D | 2/3 U | U | N | D (a) | D (a) | U (a) | U (a) | U | N (t) | D (t) |
| α, deg | 36 | 51 | 60 | 36 | No spin | 40 | 41 | No spin | 31 | No spin | 53 | | |
| ϕ, deg | 7D | 6D | 0 | 8D | | 5D | 5D | | 0 | | 2D | | |
| Ω, rps | 0.50 | 0.47 | 0.50 | 0.47 | | 0.51 | 0.54 | | 0.42 | | 0.42 | | |
| V, fps | 264 | 215 | 199 | 252 | | 252 | 227 | | 270 | | 224 | 304 | >304 |
| Turns for recovery | [l]2 3/4<br>[l]4 3/4<br>[l]8<br>[m]1 1/2<br>[m]1 3/4<br>[m]1 3/4 | ∞<br>∞ | [n]2 1/2<br>[n]2 3/4<br>[n]3 1/2 | 3<br>7<br>> 7 | | ∞<br>∞ | 6<br>∞ | | 1<br>2 1/2<br>4 | | 5<br>6<br>8<br>[o]2<br>[o]3 1/2<br>[o]4 1/4<br>[f]2 1/4<br>[f]2 1/2 | 2<br>2 | [l]1<br>[l]1 1/2<br>[l]1 1/2 |

**Loading D**

| Ailerons | Against | Against Full | | | Against 1/3 | Neutral | | | | | With | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevators | 25° U | U (p) | N (p,q) | D (q) | 2/3 U | U | N (a,p) | N (a) | D (a) | D (a) | U | N | D |
| α, deg | No spin | 34,43 | 42,73 | 41,93 | 24,41 | | 34,45 | | 44 | | | | |
| ϕ, deg | | 1U<br>10U | 16U<br>13D | 41U<br>30D | 2D<br>8U | | 7U<br>2D | | 1U | | | | |
| Ω, rps | | 0.38 | 0.38 | 0.64 | 0.49 | | 0.42 | | 0.39 | | | | |
| V, fps | | 277 | 233 | 227 | 270 | > 258 | 258 | > 304 | 270 | > 287 | > 290 | > 356 | > 336 |
| Turns for recovery | | 2<br>4 | ∞<br>∞ | ∞<br>∞ | [r,j]3<br>[r,j]>3 | [s]1/4<br>[s]1/4 | [r]> 4<br>[r]> 5 | 1<br>1 1/2 | 5 3/4<br>> 7 | [c]1/4<br>[c]1/4 | [s]1/2<br>[s]1/2 | [s]1/2<br>[s]3/4 | [c,s]1/2<br>[c,s]1 |

**Loading A, modification A**

| Ailerons | Against | | | Neutral | | | With 1/3 | With Full | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Elevators | U | N | D | U | N | D | U | U | N | D |
| α, deg | No spin | No spin | 41 | No spin | No spin | No spin | 43 | 55 | 23 | 21 |
| ϕ, deg | | | 6U | | | | 3D | 4D | 24D | 18D |
| Ω, rps | | | 0.40 | | | | 0.31 | 0.38 | 0.64 | 0.70 |
| V, fps | | | 277 | | | | 277 | 245 | 237 | 277 |
| Turns for recovery | | | 1 1/4<br>1 3/4 | | | | > 3<br>> 3 | 4 1/2<br>5 | > 4 1/2<br>> 5 | > 3<br>> 4 |

**Loading A, modification B**

| Ailerons | Against | | | | Neutral | | | With 1/3 | With Full | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevators | U | N | D (a) | D (a) | U | N | D | U | U | N | D |
| α, deg | No spin | No spin | 31, 46 | No spin | No spin | No spin | No spin | 18, 45 | 41, 52 | 25 | 26 |
| ϕ, deg | | | 4D | | | | | 7D, 6U | 2D | 8D | 6D |
| Ω, rps | | | 0.64 | | | | | 0.41 | 0.41 | 0.60 | 0.64 |
| V, fps | | | 202 | | | | | 304 | 246 | 336 | 349 |
| Turns for recovery | | | 7<br>∞ | | | | | ∞<br>∞ | ∞<br>∞ | ∞<br>∞ | 9<br>∞ |

[a]Two conditions possible.
[b]Recovery attempted by neutralization of the ailerons.
[c]Model recovers in an inverted dive.
[d]Model oscillatory in pitch.
[e]Recovery attempted by neutralization of the elevators.
[f]Recovery attempted by simultaneous reversal of rudder and elevators.
[g]Recovery attempted by simulatenous neutralization of the rudder and ailerons.
[h]Recovery attempted by simultaneous neutralization of elevators and ailerons.
[i]Recovery attempted by simultaneous reversal of the rudder and movement of ailerons full against the spin.
[j]Recovery attempted by reversal of the rudder from full with to 2/3 against the spin.
[k]Upon recovery, model goes into an inverted spin.
[l]Upon recovery, model goes into a spin in opposite direction.
[m]Recovery attempted by simultaneous reversal of rudder and elevators and movement of ailerons full with the spin.
[n]Recovery attempted by simultaneous reversal of the rudder and movement of the ailerons full with the spin.
[o]Recovery attempted by simultaneous neutralization of the ailerons and reversal of the rudder.
[p]Wandering spin.
[q]Model oscillates in roll, pitch, and yaw.
[r]Visual estimate.
[s]Recovery attempted before model reached final steeper attitude.
[t]Steep spin.

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[redacted]

CHART 6.- SPIN DATA OBTAINED WITH MODEL 6 - Concluded

| | Loading A, modification C | | | | | | | | | | Loading D, modification A | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With 1/3 | With Full | | | Against Full | | | Against 1/3 | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | U | N | D | U | N | D | $\frac{2}{3}$U | U | N | D | U | N | D |
| α, deg | No spin | No spin | 59 | No spin | No spin | No spin | 43 | 51 | 43 | 19,33 | | 48 | 53 | 38 | | 37 | | 47 | | |
| ø, deg | | | 3D, 6U | | | | 6D, 5U | 0 | 3D | 2D, 14D | | 0,11U | 2U | 7U | | 1U | | 0,11D | | |
| Ω, rps | | | 0.51 | | | | 0.38 | 0.45 | 0.50 | 0.80 | | 0.36 | 0.38 | 0.32 | | 0.31 | | 0.31 | | |
| V, fps | | | 215 | | | | 267 | 245 | 277 | 274 | >350 | 258 | 227 | 297 | >300 | 290 | >300 | 246 | | >300 |
| Turns for recovery | | | 6 1/2<br>∞ | | | | [j]>5 1/2<br>[j]>7 | ∞<br>∞ | ∞<br>∞ | ∞<br>∞ | 1/4<br>1/4 | ∞<br>∞ | >6<br>>8 | [j]3/4<br>[j]3/4 | 1/4<br>1/4 | 1/2<br>3/4 | 1/4 | 1 1/4<br>1 1/2 | | 1/4 |

| | Loading D, modification B | | | | | | | | | | | | | | Loading D, modification C | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against Full | | | | Against 1/3 | Neutral | | | | | | With | | | Against Full | | | Against 1/3 | Neutral | | | With | | |
| Elevators | 25° U | U | N | D | $\frac{2}{3}$U | 25° U (p) | U (p) | N | N | D | D | U | N | D | U | N | D | $\frac{2}{3}$U | U | N | D | U | N | D |
| α, deg | No spin | 33<br>39 | 43<br>55 | | | | 34<br>41 | 36<br>44 | | | No spin | 23<br>41 | | | | 45<br>80 | 48<br>80 | | | | 47 | | | |
| ø, deg | | 4D | 1D<br>7D | | | | 4U<br>6D | 1D<br>7D | | | | 14U<br>8D | | | | 15U<br>15D | 20U<br>22D | | | | 1U | | | |
| Ω, rps | | 0.35 | 0.36 | | | | 0.40 | 0.45 | | | | 0.41 | | | | 0.44 | 0.54 | | | | 0.42 | | | |
| V, fps | | 337 | 227 | 221 | 336 | 283 | 313 | 252 | | 283 | | 270 | 395 | 395 | >300 | 212 | 215 | >300 | >300 | >300 | 240 | >300 | >300 | >300 |
| Turns for recovery | | [r]2<br>[r]2<br>[r]2 1/2 | ∞<br>∞ | ∞<br>∞ | [jr]4<br>[jr]5 | 1/4<br>3/4 | [r]1/2<br>[r]3<br>[r]4 | ∞<br>∞ | [rt]1/2<br>[rt]1/2 | ∞<br>∞ | | [su]1<br>[su]1 | [s]1 1/4<br>[s]1 | [sc]1/4<br>[sc]1/2 | 1/2<br>3/4 | ∞<br>∞ | ∞ | [j]1/2<br>[j]1/2 | 1/2<br>1/2 | 1/2<br>3/4 | 1/4<br>1/4 | 1 1/2<br>2 1/4 | 3/4<br>1 | 1/2<br>3/4 |

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[c]Model recovers in an inverted dive.
[j]Recovery attempted by reversal of the rudder from full with to 2/3 against the spin.
[p]Wandering spin.
[r]Visual observation.
[s]Recovery attempted before model reached final altitude.
[t]Steep spin.
[u]Upon recovery model goes into a wide spiral.

[redacted]

CHART 7.- SPIN DATA OBTAINED WITH MODEL 7

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in clean condition; right erect spins]

| | Loading A, single vertical tail | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | | | | | | | Neutral | | | With | | | |
| | Full | | | 2/3 | 1/2 | | 1/3 | | | 1/4 | | | | | 1/3 | Full | | |
| Elevators | U | N | D | N | 1/5 U | N | 2/3 U | 1/5 U | N | 1/5 U | N | U | N | D | 2/3 U | U | N | D |
| α,deg | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin |
| φ,deg | | | | | | | | | | | | | | | | | | |
| Ω,rps | | | | | | | | | | | | | | | | | | |
| V,fps | | | | | | | | | | | | | | | | | | |

| | Loading A, modification A | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | Neutral | | | With | | | | |
| | Full | | | | 1/3 | | | | 1/3 | Full | | | |
| Elevators | U | N | D (a) | D (a) | 2/3 U | U | N | D | 2/3 U | U | N | D | |
| α,deg | No spin | 81 | 70 | No spin | 77 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | |
| φ,deg | | 0 | 2D | | 1U | | | | | | | | |
| Ω,rps | | 0.33 | 0.26 | | 0.26 | | | | | | | | |
| V,fps | | 186 | 186 | | 192 | | | | | | | | |

| | Loading B, modification B | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | Neutral | | | With | | | | |
| | Full | | | | 1/3 | | | | 1/3 | Full | | | |
| Elevators | U (a) | U (a) | N | D | 2/3 U | U | N | D | 2/3 U | U | N | D | |
| α,deg | 81 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | |
| φ,deg | 1D | | | | | | | | | | | | |
| Ω,rps | 0.36 | | | | | | | | | | | | |
| V,fps | 198 | | | | | | | | | | | | |

[a]Two types of spin.

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CHART 8.- SPIN DATA OBTAINED WITH MODEL 8

[Model launched erect with spinning rotation to right, rudder full right, indicated controls reversed]

| Loading | Modification | Elevator setting prior to movement if any | Aileron setting | Description of model motion before control reversal | Flight path after full rudder reversal | Flight path after simultaneous full reversal of rudder and elevator | Flight path after full elevator reversal |
|---|---|---|---|---|---|---|---|
| A | None | Full up | Full against | Extremely oscillatory; alternate rolling and yawing motion | Made from 1/4 to 3/4 of a turn and went into stalled glide | Made from 1/4 to 1/2 of a turn and went into steep glide or dive | Made 1/4 of a turn and went into steep glide or dive |
| A | -do- | ---do--- | Neutral | Very oscillatory, inner wing dropped and model yawed into spin | Made from 1/4 to 1/2 of a turn and went into stalled glide | Made 1/4 of a turn and went into steep glide or inverted spin | Made from 1/4 to 1 turn and went into steep glide or dive |
| A | -do- | ---do--- | Full with | Extremely oscillatory; alternate rolling and yawing motion | Made 1/4 of a turn and went into a stalled glide | Made 1/4 of a turn and went into dive | Made from 1/4 to 1/2 of a turn and went into steep glide or dive |
| A | -do- | Neutral | Full against | Pitched and rolled onto back; went into left spin when launched with rudder against rotation | --- | --- | --- |
| A | -do- | ---do--- | Neutral | Very oscillatory, inner wing dropped and model yawed into spin | Made 1/4 of a turn and went into stalled glide | --- | --- |
| A | -do- | ---do--- | Full with | ---do--- | Made 1/4 to 1 turn and went into stalled glide | --- | --- |
| A | -do- | Down (10°) | Full against | Pitched into dive | --- | --- | --- |
| A | -do- | ---do--- | Neutral | Extremely oscillatory; alternate rolling and yawing motions | Would probably have gone on its back after approx. 1-1/2 turns | --- | --- |
| A | -do- | ---do--- | Full with | ---do--- | Made 1/2 of a turn and rolled on back | --- | --- |
| A | A | Full up | Full against | Stalled glide | --- | --- | --- |
| A | A | ---do--- | Neutral | ---do--- | --- | --- | Went into steep dive |
| A | A | ---do--- | Full with | ---do--- | --- | --- | Went into erect spin or inverted dive |
| A | A | Neutral | Full against | ---do--- | --- | --- | --- |
| A | A | ---do--- | Neutral | ---do--- | --- | --- | --- |
| A | A | ---do--- | Full with | ---do--- | --- | --- | --- |
| A | A | Down (10°) | Full against | Pitched into dive | --- | --- | --- |
| A | A | ---do--- | Neutral | Extremely oscillatory; alternate rolling and yawing motion | Made 1/4 turn and pitched into a dive | --- | --- |
| A | A | ---do--- | Full with | ---do--- | --- | --- | --- |
| A | B | Full up | Full with | Stalled spiral glide | Straight stalled glide approx. 1/4 turn after reversal | --- | --- |
| A | B | ---do--- | Neutral | ---do--- | ---do--- | --- | --- |
| A | B | ---do--- | Full against | ---do--- | ---do--- | --- | --- |
| A | B | Neutral | Full with | Wandering, wide radius spin | Stalled glide $1\frac{3}{4}$ turns after reversal | --- | --- |
| A | B | ---do--- | Neutral | ---do--- | Stalled glide 3/4 turn after reversal | --- | --- |
| A | B | ---do--- | Full against | ---do--- | Stalled glide 1/2 turn after reversal | --- | --- |
| A | B | Full down (20°) | Full with | Spin very oscillatory in pitch and yaw (made approx. 1 turn in flat attitude and 2 in steep attitude, then repeated) | Same as before reversal | --- | --- |
| A | B | ---do--- | Neutral | Steep spin | Went into inverted stalled glide approx. $4\frac{1}{2}$ turns after | --- | --- |
| A | B | ---do--- | Full against | Went inverted | --- | --- | --- |
| B | None | Full up (30°) | Full against | Periodically pitched from a flat to a steep attitude | Steep glide, extremely oscillatory in roll and pitch | --- | --- |
| B | -do- | ---do--- | Neutral | Stalled glide, extremely oscillatory in roll | Same as before reversal | | |
| B | -do- | ---do--- | Full with | Spin very oscillatory in roll and pitch | Made 1/2 of a turn and went into stalled glide | --- | --- |

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CHART 8.- SPIN DATA OBTAINED WITH MODEL 8-CONTINUED

| Loading | Modifi-cation | Elevator setting prior to movement if any | Aileron setting | Description of model motion before control reversal | Flight path after full rudder reversal | Flight path after simultaneous full reversal of rudder and elevator | Flight path after full elevator reversal |
|---|---|---|---|---|---|---|---|
| B | None | Neutral | Full against | Rolled and pitched on back | Rolled into dive | --- | --- |
| B | -do- | ---do--- | Neutral | Stalled glide, very oscillatory in roll | Same as before reversal | --- | --- |
| B | -do- | ---do--- | Full with | ---do--- | ---do--- | --- | --- |
| B | -do- | Full down (10°) | Full against | Rolled and yawed into dive or onto back | Stalled glide, extremely oscillatory in roll | --- | --- |
| B | -do- | ---do--- | Neutral | Stalled glide, very oscillatory in yaw and pitch | Stalled glide | --- | --- |
| B | -do- | ---do--- | Full with | Stalled glide | --- | --- | --- |
| C | -do- | Full up | Full against | Stalled glide, extremely oscillatory in roll, pitch, and yaw | Stalled glide, very oscillatory in roll; rotation stopped in 1 turn | --- | --- |
| C | -do- | ---do--- | Neutral | ---do--- | Stalled glide, extremely oscillatory in roll; rotation stopped in 3/4 of a turn | --- | --- |
| C | -do- | ---do--- | Full with | Stalled glide, extremely oscillatory in roll | Same as before reversal | --- | --- |
| C | -do- | Neutral | Full against | ---do--- | ---do--- | --- | --- |
| C | -do- | ---do--- | Neutral | Steep dive | Stalled glide, very oscillatory in roll | --- | --- |
| C | -do- | ---do--- | Full with | Stalled glide | Same as before reversal | --- | --- |
| C | -do- | Full down (10°) | Full against | Model yawed and pitched into steep dive | ---do--- | --- | --- |
| C | -do- | ---do--- | Neutral | Steep glide, very oscillatory in roll | Stalled glide | --- | --- |
| C | -do- | ---do--- | Full with | Stalled glide, sometimes dived into inverted position | Model went into dive | --- | --- |
| D | -do- | Full up (30°) | Full against | Stalled glide, extremely oscillatory in roll, yaw, and pitch | Stalled glide, very oscillatory in roll | --- | --- |
| D | -do- | ---do--- | Neutral | ---do--- | ---do--- | --- | --- |
| D | -do- | ---do--- | Full with | ---do--- | ---do--- | --- | --- |
| D | -do- | Neutral | Full against | Model rolled and yawed into steep dive | Same as before reversal | --- | --- |
| D | -do- | ---do--- | Neutral | Moderately steep spin, very oscillatory in roll | Made $1\frac{1}{2}$ turns and went into steep stalled glide | --- | --- |
| D | -do- | ---do--- | Full with | Stalled glide, yawed and banked | Stalled glide | --- | --- |
| D | -do- | Full down (10°) | Full against | Rolled and yawed into steep dive | Dive | --- | --- |
| D | -do- | ---do--- | Neutral | Very oscillatory spin, whipping motion in roll and yaw | Made more than 1 turn and went into dive | --- | --- |
| D | -do- | ---do--- | Full with | ---do--- | --- | --- | --- |
| E | -do- | Full up | Full against | Violently oscillatory in roll, yaw, and pitch | --- | --- | --- |
| E | -do- | ---do--- | Neutral | Stalled glide, very oscillatory in roll and yaw | --- | --- | --- |
| E | -do- | ---do--- | Full with | Stalled glide, very oscillatory in roll | --- | --- | --- |
| E | -do- | Neutral | Full against | Pitched and rolled onto back | --- | --- | --- |
| E | -do- | ---do--- | Neutral | Stalled glide, very oscillatory in roll, sometimes rolled onto back | --- | --- | --- |
| E | -do- | ---do--- | Full with | Stalled glide, very oscillatory in roll | --- | --- | --- |
| E | -do- | Full down (10°) | Full against | Rolled and pitched onto back | --- | --- | --- |
| E | -do- | ---do--- | Neutral | Rolled and pitched into vertical or inverted position | --- | --- | --- |
| E | -do- | ---do--- | Full with | Stalled glide, slightly oscillatory in roll | --- | --- | --- |

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CHART 8.- SPIN DATA OBTAINED WITH MODEL 8-CONTINUED

| Loading | Modification | Elevator setting prior to movement if any | Aileron setting | Description of model motion before control reversal | Flight path after full rudder reversal | Flight path after simultaneous full reversal of rudder and elevator | Flight path after full elevator reversal |
|---|---|---|---|---|---|---|---|
| F | None | Full up (30°) | Full against | Stalled glide | Stalled glide, oscillatory in roll | --- | --- |
| F | -do- | ---do--- | Neutral | ---do--- | Same as before reversal | --- | --- |
| F | -do- | ---do--- | Full with | ---do--- | Dive or stalled glide | --- | --- |
| F | -do- | Neutral | Full against | Steep wandering and very oscillatory spin with whip | Same as before reversal | --- | --- |
| F | -do- | ---do--- | Neutral | ---do--- | Went into a steep dive in greater than $1\frac{1}{4}$ turns | --- | --- |
| F | -do- | ---do--- | Full with | ---do--- | --- | --- | --- |
| F | -do- | Full down (10°) | Full against | Steep spin, extremely wandering and oscillatory | Same as before reversal | --- | --- |
| F | -do- | ---do--- | Neutral | Steep wandering and oscillatory spin with whip | Went into inverted dive | --- | --- |
| F | -do- | ---do--- | Full with | ---do--- | Same as before reversal | --- | --- |
| G | -do- | Full up | Full with | Stalled spiral glide | --- | --- | --- |
| G | -do- | ---do--- | Neutral | Stalled glide | --- | --- | --- |
| G | -do- | ---do--- | Full against | ---do--- | --- | --- | --- |
| G | -do- | Neutral | Full with | Spiral dive | --- | --- | --- |
| G | -do- | ---do--- | Neutral | Made 1/2 turn, dived a short distance; motion is repeated | Same as before reversal | --- | --- |
| G | -do- | ---do--- | Full against | Very oscillatory with wide radius; might be spin or spiral glide | Made 1/4 turn and glided (moderately steep) | --- | --- |
| G | -do- | Full down (20°) | Full with | Wandering spin with large pitching oscillations; very steep | Made 1 to $2\frac{1}{2}$ turns and went into inverted spins | --- | --- |
| G | -do- | ---do--- | Neutral | ---do--- | Same as before reversal | --- | --- |
| G | -do- | ---do--- | Full against | Pitched into inverted spin | --- | --- | --- |
| G | A | Full up | Full with | Spiral glide | --- | --- | --- |
| G | A | ---do--- | Neutral | ---do--- | --- | --- | --- |
| G | A | ---do--- | Full against | ---do--- | --- | --- | --- |
| G | A | Neutral | Full with | ---do--- | Same as before reversal | --- | --- |
| G | A | ---do--- | Neutral | ---do--- | ---do--- | --- | --- |
| G | A | ---do--- | Full against | Wandering spin; one yawing oscillation per turn of spin | Made 1/2 turn and went into stalled glide | --- | --- |
| G | A | Full down (20°) | Full with | Spiral dive | Made 1/4 turn and went into inverted dive | --- | --- |
| G | A | ---do--- | Neutral | ---do--- | Made 3/4 turn and went into inverted dive | --- | --- |
| G | A | ---do--- | Full against | Went into inverted spin | --- | --- | --- |
| H | None | Full up | Full with | Stalled glide | --- | --- | --- |
| H | -do- | ---do--- | Neutral | ---do--- | --- | --- | --- |
| H | -do- | ---do--- | Full against | ---do--- | --- | --- | --- |
| H | -do- | Neutral | Full with | Wide spiral glide oscillatory in pitch | Same as before reversal | --- | --- |
| H | -do- | ---do--- | Neutral | ---do--- | ---do--- | --- | --- |
| H | -do- | ---do--- | Full against | Wide radius spin | Made 1/2 turn and dived | --- | --- |
| H | -do- | Full down (20°) | Full with | Spin, oscillatory in roll, pitch, and yaw | Same as before reversal | --- | --- |
| H | -do- | ---do--- | Neutral | Spin, oscillatory in pitch and yaw | ---do--- | --- | --- |
| H | -do- | ---do--- | Full against | Spin, oscillatory in roll, pitch, and yaw | Made 3/4 turn and went into stalled glide; or made 1/4 turn and went into steep inverted dive | --- | --- |

UNCLASSIFIED

CHART 8.- SPIN DATA OBTAINED WITH MODEL 8-CONCLUDED

| Loading | Modification | Elevator setting prior to movement if any | Aileron setting | Description of model motion before control reversal | Flight path after full rudder reversal | Flight path after simultaneous full reversal of rudder and elevator | Flight path after full elevator reversal |
|---|---|---|---|---|---|---|---|
| I | None | Full up | Full with | Went into a stalled glide | --- | --- | --- |
| I | -do- | ---do--- | Neutral | ---do--- | --- | --- | --- |
| I | -do- | ---do--- | Full against | ---do--- | --- | --- | --- |
| I | -do- | Neutral | Full with | Steep spin | Same as before reversal | --- | --- |
| I | -do- | ---do--- | Neutral | ---do--- | ---do--- | --- | --- |
| I | -do- | ---do--- | Full against | ---do--- | Dived out after approx. 1 turn | --- | --- |

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CHART 9.- SPIN DATA OBTAINED WITH MODEL 9

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in the clean condition with the landing gear extended and stabilizer setting zero and recoveries were attempted by rapid full rudder reversal: right erect spins]

| | Loading A | | | | | | | Loading B | | | | | | | Loading C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | Neutral | | | With | | Against | | Neutral | | | With | | Against | | | Neutral | | | With | | |
| Elevators | U (a) | D | U (a) | N (a) | D | U (a) | D (a) | U (a) | D (c) | U (a) | N (a) | D | U (ad) | D (ad) | U (f) | N | D (f) | U (f) | N (a) | D (a) | U (f) | N | D (a) |
| α, deg | - | - | - | - | No spin | - | - | - | - | - | - | No spin | -- | -- | - | - | - | - | - | - | - | - | - |
| ϕ, deg | - | - | - | - | | - | - | - | - | - | - | | -- | -- | - | - | - | - | - | - | - | - | - |
| Ω, rps | - | - | - | - | | - | - | - | - | - | - | | -- | -- | - | - | - | - | - | - | - | - | - |
| V, fps | > 245 | - | > 245 | > 245 | | > 245 | >245 | >245 | >245 | >245 | >245 | | >245 | >245 | >245 | - | >245 | >245 | >245 | >245 | >245 | - | >245 |
| Turns for recovery | - | - | - | [b]m 2$\frac{1}{4}$ | | - | - | m 2$\frac{1}{4}$ | [e]- | - | - | | -- | -- | m 2$\frac{1}{2}$ | - | m 2$\frac{1}{2}$ | m 2$\frac{1}{2}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | - | m 2$\frac{1}{4}$ |

| | Loading D | | | | | | | Loading E | | | | | | | | | | Loading F | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | Neutral | | | With | | Against | | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (f) | D | U (f) | N (a) | D (a) | U (f) | D (a) | U (f) | N | D (ag) | D (g) | U (f) | N (f) | D (a) | U (f) | N | D (a) | U (f) | N (f) | D | U (f) | N (f) | D (f) | U | N | D (f) |
| α, deg | - | 28 | - | - | - | - | - | - | - | - | 58 | - | - | - | - | - | - | - | - | 53 | - | - | - | 43 | 38 | - |
| ϕ, deg | - | 3U | - | - | - | - | - | - | - | - | 1D | - | - | - | - | - | - | - | - | 2D | - | - | - | 5D | 7D | - |
| Ω, rps | - | 0.61 | - | - | - | - | - | - | - | - | 0.53 | - | - | - | - | - | - | - | - | 0.76 | - | - | - | 0.66 | 0.80 | - |
| V, fps | >245 | 162 | >245 | >245 | >245 | >245 | >245 | >245 | - | >245 | 89 | >245 | >245 | >245 | >245 | - | >245 | >245 | >245 | 104 | >245 | >245 | >245 | 147 | 169 | >245 |
| Turns for recovery | m 2$\frac{1}{2}$ | 3 | m 2$\frac{1}{2}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | - | - | ∞ | m 2$\frac{1}{2}$ | m 2$\frac{1}{2}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | - | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | m 2$\frac{1}{2}$ | ∞ | m 2$\frac{1}{2}$ | m 2$\frac{1}{2}$ | m 2$\frac{1}{2}$ | ∞ | - | m 2$\frac{1}{2}$ |

| | Loading G | | | | | | | Loading H | | | | | | | Loading I | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | Neutral | | | With | | Against | | Neutral | | | With | | Against | | | | Neutral | | | With | | |
| Elevators | U | D (i) | U (a) | N (a) | D (a) | U | D | U (f) | D | J (jk) | N (jk) | D (fj) | U (j) | D (i) | U (a) | N (l) | N (l) | D | U | N | D | U | N | D (a) |
| α, deg | No spin | - | - | - | - | 43 | No spin | - | 69 | - | - | - | 39 | - | - | No spin | - | 67 | 43 | 62 | 59 | 49 | 45 | - |
| ϕ, deg | | - | - | - | - | 1D | | - | 4D | - | - | - | 7D | - | - | | - | 1D | 0 | 1D | 2D | 1D | 0 | - |
| Ω, rps | | - | - | - | - | 0.88 | | - | 0.72 | - | - | - | 0.57 | - | - | | - | 0.78 | 0.64 | 0.71 | 0.73 | 0.68 | 0.66 | - |
| V, fps | | >245 | >245 | >245 | >245 | 147 | | 245 | 116 | >245 | >245 | >245 | 184 | >245 | >245 | | 184 | 122 | 202 | 155 | 145 | 158 | 184 | >245 |
| Turns for recovery | | m 2 | m 2$\frac{1}{4}$ | m 2$\frac{1}{4}$ | < 2$\frac{1}{4}$ | 8 | | m 2$\frac{1}{2}$ | ∞ | m 2$\frac{1}{4}$ | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | m 2$\frac{1}{4}$ | > 2 | - | | $\frac{3}{4}$ | ∞ | ∞ 8 | ∞ | ∞ | ∞ | ∞ | - |

| | Loading A leading edge of stabilizer 30° down | | | | | | Loading C leading edge of stabilizer 30° down | | | | | | | Loading F leading edge of stabilizer 30° down | | | | | | | | Loading I, leading edge of stabilizer 30° down | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | Neutral | | With | | Against | | Neutral | | | With | | Against | | | Neutral | | | With | | Against | | |
| Elevators | U | D (c) | U | N (c) | U | D | U | D (c) | U (c) | N (c) | D (c) | U (a) | D (c) | U | N | D | U (k) | N (f) | D | U | D | U | N | D |
| α, deg | No spin | - | - | - | 59 | 59 | No spin | - | - | - | - | - | - | No spin | - | No spin | - | - | - | 58 | 54 | No spin | No spin | - |
| ϕ, deg | | - | - | - | 3D | 2D | | - | - | - | - | - | - | | - | | - | - | - | 2D | 3D | | | - |
| Ω, rps | | - | - | - | 0.57 | 0.77 | | - | - | - | - | - | - | | - | | - | - | - | 0.72 | 0.72 | | | - |
| V, fps | | - | - | - | 87 | 87 | | - | - | - | - | > 245 | - | | - | | >245 | >245 | >245 | 125 | 124 | | | 191 |
| Turns for recovery | | [h]5 | - | [h]5 | ∞ | ∞ | | [h]5 | [h]4 | [h]4 | [h]5 | m 2$\frac{1}{4}$ | [h]5 | | - | | m 2$\frac{1}{4}$ | m 2$\frac{1}{2}$ | - | ∞ | ∞ | | | >6$\frac{1}{2}$ |

| | Loading I rudder-against spins landing gear retracted | | | | | | | | | Loading I leading edge of stabilizer 30° down landing gear retracted | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | | Neutral | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D (a) | U | N | D (l) | D (l) | U | D | U | N | D |
| α, deg | No spin | No spin | - | No spin | - | - | - | - | - | No spin | No spin | No spin [i] | - | 40 | - | 64 | - | 65 |
| ϕ, deg | | | - | | - | - | - | - | - | | | | - | 2D | - | 0 | - | 1D |
| Ω, rps | | | - | | - | - | - | - | - | | | | - | 0.72 | - | 0.68 | 0.77 | 0.84 |
| V, fps | | | 127 | | 165 | 149 | 160 | 195 | > 245 | | | | 173 | 216 | - | 160 | 142 | 136 |
| Turns for recovery | | | - | | - | - | - | - | - | | | | [h]6 | [h]6 | - | ∞ | ∞ | ∞ |

[a]Steep spin.
[b]Recovery attempted before model reached final steeper attitude
[c]Moderately steep spin with increasing radius.
[d]Model attitude did not change after rudder reversal.
[e]Slow recovery.
[f]Steep spin with increasing radius.
[g]Two types of spin.
[h]When launched in a flat attitude with the rudder against the rotation, the model ceased rotating after indicated number of turns.
[i]Steep spin with small radius.
[j]Wandering spin, rate of rotation varies.
[k]Wide radius of spin
[l]Two conditions possible.
[m]The model recovered in less turns than indicated.

CHART 10.- SPIN DATA OBTAINED WITH MODEL 10

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in the clean condition and recoveries were attempted by rapid full rudder reversal, propellers off except where indicated]

| | Loading A, left erect spins | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | | | | Neutral | | | | | With | | |
| | Full | | | 1/2 | 1/3 | | 1/4 | | | | | | | | | |
| Elevators | U | N (a) | D (a) | D (a) | $\frac{2}{3}$ U (b) | $\frac{2}{3}$ U (a)(b) | D (b) | D (b) | U (b) | U (a)(b) | N (b) | N (a)(b) | D | U (a) | N | D |
| α, deg | No spin | 68<br>82 | 69<br>77 | 65<br>76 | ----- | 74<br>85 | --- | ---- | No spin | 64<br>72 | ----- | 48<br>72 | ----- | 60<br>76 | ----- | ----- |
| ϕ, deg | | 7D<br>3U | 7D<br>5U | 4D<br>4U | ----- | 6D<br>3U | --- | ---- | | 2D<br>4U | ----- | 3D<br>2U | ----- | 3D<br>3U | ----- | ----- |
| Ω, rps | | 0.71 | 0.59 | 0.60 | ----- | 0.78 | --- | 0.61 | | 0.41 | 0.55 | 0.54 | ----- | 0.56 | ----- | ----- |
| V, fps | | 182 | 194 | 196 | >304 | 196 | >304 | 199 | | 262 | 199 | 274 | >304 | 210 | >304 | >304 |
| Turns for recovery | | [c]5 ∞<br>[c]7 1/2 | ∞ | ∞ | [d,e]1<br>[d,e]1 1/2 | [e]∞<br>[f]>4 1/2<br>[f]>5 1/2<br>[g]∞ | [d]3<br>[d]4 | ∞ | | 1<br>1 1/2 | [h]∞ | [h]1 1/2 | [d]1 1/2<br>[d]2 | ∞ | [d]1<br>[d]2 | [d]1 |

| | Loading A, right erect spins | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | Neutral | | | With | | | | |
| | Full | | | 1/3 | | | | 1/3 | | Full | | |
| Elevators | U | N | D (a)(i) | $\frac{2}{3}$ U | U | N (a) | D | $\frac{2}{3}$ U (b) | $\frac{2}{3}$ U (a)(b) | U | N | D |
| α, deg | No spin | ------- | 61<br>89 | --------- | ------ | 42<br>50 | -------- | ----- | 57<br>63 | ------ | ------- | ------ |
| ϕ, deg | | ------- | 15D<br>10U | --------- | ------ | 7D<br>6U | -------- | ----- | 2D<br>2U | ------ | ------- | ------ |
| Ω, rps | | 0.72 | 0.52 | --------- | ------ | 0.55 | -------- | ----- | 0.52 | 0.51 | ------- | ------ |
| V, fps | | 188 | 188 | > 304 | >338 | 274 | >370 | >332 | 244 | 244 | >304 | > 304 |
| Turns for recovery | | ∞ | ∞ | [d,e]3/4<br>[d,e]1 1/2 | [d]1/2<br>[d]1 | 2<br>7 | [d]2<br>[d]3 3/4 | [d,e]2<br>[d,e]2 | [e]∞ | ∞ | [d]2<br>[d]2 1/2 | [d]3/4<br>[d]1 1/2 |

| | Loading A, left spins propeller pitch = 30° | | | | Loading A, right erect spins, stability flaps deflected 25° down | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | With | | | Against | | | | | Neutral | | With | | |
| | 1/3 | 1/3 | | Full | Full | | | | 1/3 | | | 1/3 | | |
| Elevators | $\frac{2}{3}$ U | $\frac{2}{3}$ U (b) | $\frac{2}{3}$ U (a)(b) | U (a) | U | N (a)(j) | D (a)(b) | D (a)(b) | $\frac{2}{3}$ U | U | N (k) | $\frac{2}{3}$ U (a) | U | N (k) |
| α, deg | No spin | No spin | 40<br>57 | 40<br>48 | No spin | 70<br>86 | 64<br>79 | 50<br>57 | -------- | No spin | --- | 40<br>48 | ------ | ------ |
| ϕ, deg | | | 2D<br>7U | 0<br>5U | | 3D<br>4U | 12D<br>8U | 4D<br>3U | -------- | | --- | 4D<br>4U | ------ | ------ |
| Ω, rps | | | 0.33 | 0.30 | | 0.45 | 0.52 | 0.45 | 0.40 | | --- | 0.36 | 0.40 | 0.42 |
| V, fps | | | 241 | 244 | | 177 | 199 | 233 | 227 | | > 340 | 280 | 262 | > 370 |
| Turns for recovery | | | [e]>6 | >2 3/4<br>> 6 | | >5<br>∞ | ∞ | 5 | [e]>1<br>[e]1 1/4<br>[e]1 1/2 | | [l]3<br>[l]3 | [e]>1 1/2<br>[e]> 3 | >3 1/2<br>>6 | >2<br>>3 |

[a]Oscillatory spin; range of values or average value given.

[b]Two conditions possible.

[c]Recovery attempted by simultaneous reversal of rudders to full against the spin and stick to longitudinally full back.

[d]Recovery attempted before final steep attitude.

[e]Recovery attempted by reversing rudders to 2/3 against the spin.

[f]Recovery attempted by simultaneous reversal of rudders to full against the spin and of stick to longitudally full back and laterally full against the spin.

[g]Recovery attempted by simultaneous reversal of rudders to full against the spin and of stick longitudinally forward and laterally full with the spin.

[h]Visual estimate.

[i]Wide radius spin.

[j]Wandering spin.

[k]Steep spin.

[l]Model recovers in a steep dive.

CHART 11.- SPIN DATA OBTAINED WITH MODEL 11

[Unless otherwise indicated, steady spin data are for rudder-with spins of the model in the clean condition and recoveries were attempted by rapid full rudder reversal, elevator U, N, and D signifies stick positions of back, neutral, and forward; right erect spins]

| | Loading A, rudders against the spin | | | | | | | | | Loading A | | | | | | | | | Loading A, flaps down 45° | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | | With | | |
| Elevators | U (a) | N (a) | D (a) | U (b) | N (b) | D (b) | U (c) | N (c) | D (c) | U (a) | N (a) | D (a) | U (d) | N (d) | D (d) | U (b) | N (b) | D (b) | U | N | D (d) | U (dg) | U (dg) | N (d) | D (d) | U (b) | N | D (b) |
| α, deg | - | - | - | - | - | - | - | - | - | - | - | - | 82 | 86 | 83 | - | - | - | 90 | 90 | 81 | 84 | 88 | 86 | 84 | - | - | - |
| ϕ, deg | - | - | - | - | - | - | - | - | - | - | - | - | 41D 30U | 39D 38U | 32D 29U | - | - | - | 5U | 6U | 36D 50U | 20D 25U | 3D 9U | 8D 11U | 19D 18U | - | - | - |
| Ω, rps | - | - | - | - | - | - | - | - | - | - | - | - | 0.13 | 0.08 | 0.10 | - | - | - | 0.69 | 0.04 | 0.22 | 0.18 | 0.36 | 0.15 | 0.19 | - | - | - |
| V, fps | - | - | - | - | - | - | - | - | - | - | - | - | 121 | 121 | 118 | - | - | - | 107 | 113 | 123 | 118 | 118 | 116 | 118 | - | - | - |
| Turns for recovery | - | - | - | - | - | - | - | - | - | - | - | - | [e]$\frac{1}{2}$ | [e]$\frac{1}{4}$ | [e]$\frac{3}{4}$ | - | - | - | ---- | ---- | ---- | --- | --- | --- | --- | - | - | - |

| | Loading B | | | | | | | | | Loading C | | | | | | | | | Loading D | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U (a) | N | D (a) | U (a) | N (a) | D (a) | U (b) | N | D (b) | U (a) | N | D (a) | U (d) | N | D (d) | U (b) | N | D (b) | U (a) | N | D (a) | U (d) | N (d) | D | U (b) | N | D (b) |
| α, deg | - | - | - | - | - | - | - | - | - | - | - | - | 82 | - | 80 | - | - | - | - | - | - | 80 | 83 | - | - | - | - |
| ϕ, deg | - | - | - | - | - | - | - | - | - | - | - | - | 33D 20U | - | 30D 26U | - | - | - | - | - | - | 19D 24U | 42D 39U | - | - | - | - |
| Ω, rps | - | - | - | - | - | - | - | - | - | - | - | - | 0.10 | - | 0.12 | - | - | - | - | - | - | 0.08 | 0.06 | - | - | - | - |
| V, fps | - | - | - | - | - | - | - | - | - | - | - | - | 118 | - | 118 | - | - | - | - | - | - | 121 | 121 | - | - | - | - |
| Turns for recovery | - | - | - | - | - | - | - | - | - | - | - | - | [e]$\frac{3}{4}$ | - | [e]$\frac{1}{2}$ | - | - | - | - | - | - | [e]$\frac{3}{4}$ | [e]$\frac{3}{4}$ | - | - | - | - |

| | Loading E | | | | | | | | | Loading F | | | | | | | | | Loading G | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | | With | | |
| Elevators | U (a) | N | D (a) | U (a) | N | D (a) | U (b) | N | D (b) | U (a) | N | D (a) | U (d) | N | D (d) | U (b) | N | D (b) | U (a) | N (a) | D (a) | U | N | D (g) | D (g) | U (h) | N (h) | D (i) |
| α, deg | - | - | - | - | - | - | - | - | - | - | - | - | 76 | --- | 72 | - | - | - | - | - | - | 56 | 57 | 42 | 61 | - | - | - |
| ϕ, deg | - | - | - | - | - | - | - | - | - | - | - | - | 22D 32U | --- | 17D 12U | - | - | - | - | - | - | 3D | 2D | 6U | 1D | - | - | - |
| Ω, rps | - | - | - | - | - | - | - | - | - | - | - | - | 0.08 | --- | --- | - | - | - | - | - | - | 0.15 | 0.15 | 0.20 | --- | - | - | - |
| V, fps | - | - | - | - | - | - | - | - | - | - | - | - | 123 | 123 | 121 | - | - | - | - | - | - | 125 | 129 | 138 | 135 | - | - | - |
| Turns for recovery | - | - | - | - | - | - | - | - | - | - | - | - | [e]$\frac{1}{4}$ | [e]$\frac{1}{2}$ | [e]$\frac{1}{4}$ | - | - | - | - | - | - | [f]$\frac{1}{2}$ | [f]$\frac{3}{4}$ | >10 | [f]$\frac{3}{4}$ [f]$1\frac{1}{2}$ | - | - | - |

| | Loading H | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | |
| Elevators | U | N | D | U | N | D | U | N | D |
| α, deg | ---- | 58 | 46 | 58 | 52 | 41 | 32 | 33 | 35 |
| ϕ, deg | ---- | 8U | 14U | 5U | 6U | 12U | 4U | 6U | 9U |
| Ω, rps | 0.39 | 0.38 | 0.40 | 0.41 | 0.39 | 0.42 | 0.43 | 0.42 | 0.46 |
| V, fps | 123 | 129 | 135 | 118 | 123 | 141 | 160 | 157 | 160 |
| Turns for recovery | ∞ | >5 | ∞ | ∞ | ∞ | ∞ | $>2\frac{1}{2}$ | $>4\frac{1}{2}$ | ∞ |

[a]Oscillated violently in pitch and roll. Rate of rotation decreased as the violence of the oscillations increased.
[b]Initial rotation stopped. Fuselage remained approximately horizontal.
[c]Initial rotation stopped. Model then began to rotate in opposite direction and oscillated violently in pitch and roll. Rate of rotation decreased as violence of the oscillations increased.
[d]Oscillated in roll.
[e]Fuselage remained approximately horizontal after rotation stopped in number of turns indicated.
[f]Model nosed over into steep dive after rotation stopped in number of turns indicated.
[g]Two types of spin.
[h]Slid around with large radius. Nose approximately 40° below horizontal.
[i]Slid around with large radius. Nose approximately 40° below horizontal. After a few turns nosed over and went into inverted dive.

CHART 11.- SPIN DATA OBTAINED WITH MODEL 11 (CONCLUDED)

| | Loading A, landing condition | | | | | | | | | Loading A | | | Loading A, flaps down 45° | | | Loading A | | | Loading A, flaps down 45° | | | Loading A, freely rotating propeller installed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Modification A | | | Modification A | | | Modification B | | | Modification B | | | Against | | | Neutral | | | With | | |
| Elevators | U (d) | N (d) | D (d) | U (d) | N (d) | D (d) | U (b) | N | D (b) | U (b) | N (b) | D (j) | U (d) | N (d) | D (j) | U (j) | N (j) | D (k) | U (d) | N | D (k) | U (a) | N (a) | D (a) | U | N (d) | D (d) | U (c) | N (c) | D (b) |
| α, deg | 83 | 80 | 68 | 82 | 89 | 78 | - | - | - | - | - | - | 75 | 79 | - | - | - | - | 79 | 83 | - | - | - | - | - | 65 | 80 | - | - | - |
| ϕ, deg | 39D 51U | 42D 48U | 41D 44U | 21D 25U | 16D 23U | 20D 18U | - | - | - | - | - | - | 16D 12U | 21D 17U | - | - | - | - | 41D 26U | 5U | - | - | - | - | - - | 36D 31U | 28D 25U | - | - | - |
| Ω, rps | 0.15 | 0.14 | 0.17 | 0.17 | 0.13 | 0.14 | - | - | - | - | - | - | 0.1[illegible] | 0.11 | - | - | - | - | 0.31 | 0.27 | - | - | - | - | - | 0.07 | 0.10 | - | - | - |
| V, fps | 123 | 121 | 121 | 121 | 118 | 121 | - | - | - | - | - | - | 116 | 116 | - | - | - | - | 107 | 107 | - | - | - | - | 121 | 121 | 118 | - | - | - |
| Turns for recovery | $>3\frac{1}{2}$ | $^{e}1\frac{3}{4}$ | $>5$ | $^{e}1$ | $^{e}1$ | $^{e}\frac{3}{4}$ | - | - | - | - | - | - | $^{e}1\frac{1}{4}$ | $^{e}\frac{1}{2}$ | - | - | - | - | $^{l}2\frac{3}{4}$ | $^{l}2$ | - | - | - | - | $^{e}\frac{1}{2}$ | $^{e}\frac{1}{2}$ | $^{e}\frac{1}{2}$ | - | - | - |

| | Loading A, modification C | | | | | | | | | Loading A, modification D | | | | | | | | | Loading A, modification E | | | | | | | | | Loading A, modification F. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D (a) | U | N | D (j) | U | N | D (j) | U | N | D (a) | U | N | D (m) | U | N | D (m) | U (a) | N | D (a) | U (d) | N (d) | D (b) | U (b) | N | D (b) | U (a) | N (a) | D (a) | U (n) | N (n) | D (n) | U (b) | N (b) | D (b) |
| α, deg | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 76 | 80 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ϕ, deg | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 34D 19U | 34D 46U | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ω, rps | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.08 | 0.14 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| V, fps | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 127 | 129 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Turns for recovery | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | $^{e}\frac{3}{4}$ | $^{e}\frac{1}{2}$ | - | - | - | - | - | - | - | - | - | - | - | - | - |

| | Loading A, modification G | | | | | | | | | Loading A, modification H | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | | Neutral | | | With | | |
| Elevators | U | N | D (a) | U | N | D (d) | U | N | D (b) | U | N | D (a) | U | N | D (d) | U | N | D (b) |
| α, deg | - | - | - | - | - | 78 | - | - | - | - | - | - | - | - | 84 | - | - | - |
| ϕ, deg | - | - | - | - | - | 12D 9U | - | - | - | - | - | - | - | - | 20D 30U | - | - | - |
| Ω, rps | - | - | - | - | - | --- | - | - | - | - | - | - | - | - | --- | - | - | - |
| V, fps | - | - | - | - | - | 121 | - | - | - | - | - | - | - | - | 121 | - | - | - |
| Turns for recovery | - | - | - | - | - | $^{e}\frac{3}{4}$ | - | - | - | - | - | - | - | - | $^{e}\frac{3}{4}$ | - | - | - |

NACA

[a] Oscillated violently in pitch and roll. Rate of rotation decreased as the violence of the oscillations increased.
[b] Initial rotation stopped. Fuselage remained approximately horizontal.
[c] Initial rotation stopped. Model then began to rotate in opposite direction and oscillated violently in pitch and roll. Rate of rotation decreased as violence of the oscillations increased.
[d] Oscillated in roll.
[e] Fuselage remained approximately horizontal.
[j] Initial rotation stopped. Glided forward rapidly with nose approximately 15° below horizontal.
[k] Initial rotation stopped. Model nosed over into steep dive.
[l] Glided forward rapidly with nose approximately 15° below horizontal.
[m] Initial rotation stopped. Glided forward for a few feet 35° below horizontal and then nosed over into a steep dive.
[n] Initial rotation stopped. Glided with slight rotation to right. Fuselage approximately horizontal. Oscillation in roll of approximately ±25°.

CHART 12.- SPIN DATA OBTAINED WITH MODEL 12

[Unless otherwise indicated, steady-spin data are for rudder-with spins of the model in the clean condition and recoveries were attempted by rapid full rudder reversal; elevator U, N, and D signifies stick positions of back, neutral, and forward; right erect spins]

| | Loading A, right spins | | | | | | | | | | | | | Loading A, left spins | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | Neutral | | | | With | | | | Against | | | | Neutral | | | | With | | | | | |
| Elevators | U (a) | N (ab) | N (bc) | D (c) | Free | U (d) | N (d) | D (d) | Free (e) | U (d) | N | D (d) | Free (d) | U (a) | N (a) | D (c) | Free (c) | U (d) | N (d) | D (c) | Free (c) | U (d) | N (d) | D (bd) | D (bi) | Free (bd) | Free (b) |
| α, deg | 90<br>74 | 95<br>59 | No spin | No spin | No spin | 74 | 91<br>71 | 76<br>58 | 73<br>62 | 88<br>62 | --- | 97<br>66 | 83<br>57 | 82<br>54 | 94<br>55 | No spin | No spin | 66<br>54 | 86<br>69 | No spin | No spin | 73<br>62 | 97<br>64 | 74<br>61 | --- | 79<br>52 | No spin |
| φ, deg | 6U<br>8D | 9U<br>17D | | | | 12U<br>18D | 22U<br>5D | 19U<br>12D | 18U<br>7D | 18U<br>19D | --- | 6U<br>18D | 10U<br>15D | 10U<br>6D | 2U | | | 9U<br>12D | 13U<br>15D | | | 12U<br>12D | 19U<br>24D | 10U<br>7D | --- | 11U<br>21D | |
| Ω, rps | 0.19 | 0.15 | | | | 0.19 | 0.21 | 0.26 | 0.20 | 0.20 | 0.13 | 0.21 | 0.21 | --- | 0.11 | | | 0.13 | 0.11 | | | 0.15 | 0.09 | 0.16 | --- | 0.16 | |
| V, fps | 182 | 182 | | | | 182 | 171 | 174 | 171 | 171 | 171 | 171 | 166 | 179 | 171 | | | 171 | 171 | | | 171 | 161 | 171 | --- | 185 | |
| Turns for recovery | $^{e}\frac{3}{4}$ | $^{f}\frac{1}{2}$ | | | | $^{e}1$ | $^{e}1$ | $^{g}1\frac{1}{4}$ | $^{g}\frac{1}{2}$ | $^{e}\frac{1}{2}$ | $^{f}\frac{1}{2}$ | $^{g}1$<br>$^{g}1\frac{1}{2}$ | $^{h}1\frac{1}{2}$ | $^{f}\frac{1}{2}$ | $^{e}\frac{1}{2}$ | | | $^{e}\frac{1}{4}$ | $^{f}\frac{1}{4}$ | | | $^{e}\frac{1}{4}$ | $^{e}\frac{1}{4}$ | $^{h}\frac{1}{2}$<br>$^{h}1$ | --- | $^{f}\frac{3}{4}$ | |

| | Loading A, wing-tip trimmers used in conjunction with the ailerons, 1 to 1 deflection ratio between ailerons and the trimmers | | | | | | | Loading A, wing-tip trimmers used in conjunction with the rudders, 1 to 1 deflection ratio between the rudders and the trimmers[i]. Trimmer moves up as adjacent rudder moves outboard. | | | | | | | | | | | | Loading A, wing-tip trimmer used in conjunction with the elevator. 2 to 1 deflection ratio between the elevator and the trimmers . Trailing edge of trimmer moves up as trailing edge of elevator moves down. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | With | | | | Against | | | Neutral | | | | With | | | | | Against | | Neutral | | With | |
| Elevators | U (c) | D (c) | Free (c) | U (a) | D (ab) | D (bi) | Free (a) | U (j) | D (j) | Free (j) | U (j) | N (dk) | D | Free (j) | U (d) | N (d) | D (j) | Free (ab) | Free (bj) | U (c) | D (c) | U (c) | D (d) | U (d) | D (dl) |
| α, deg | No spin | No spin | No spin | 94<br>63 | 78<br>59 | ---- | 71<br>56 | No spin | No spin | No spin | No spin | 81<br>71 | No spin | No spin | 65 | 88<br>60 | No spin | 74<br>41 | No spin | No spin | No spin | No spin | 60<br>87 | 92<br>54 | 92<br>53 |
| φ, deg | | | | 29U<br>31D | 11U<br>24D | ---- | 2U<br>16D | | | | | 1U<br>43D | | | 12U<br>11D | 38U<br>13D | | 2U<br>14D | | | | | 3U<br>31U | 44U<br>47D | 23U<br>22D |
| Ω, rps | | | | 0.17 | 0.18 | ---- | 0.17 | | | | | 0.08 | | | 0.12 | 0.12 | | 0.16 | | | | | 0.18 | 0.21 | 0.18 |
| V, fps | | | | 171 | 174 | ---- | 174 | | | | | 171 | | | 182 | 189 | | 198 | | | | | 174 | 189 | 171 |
| Turns for recovery | | | | $^{e}\frac{1}{2}$ | $^{e}1$ | ---- | $^{e}\frac{1}{2}$ | | | | | $^{e}\frac{1}{4}$ | | | $^{e}\frac{3}{4}$ | $^{e}\frac{1}{2}$ | | ---- | | | | | $^{h}1\frac{1}{4}$ | $^{e}1\frac{1}{4}$ | $^{h}\frac{3}{4}$ |

| | Loading B | | | | | | | | | | | | | Loading C | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | Neutral | | | | | With | | | | Against | | | Neutral | | | | With | | |
| Elevators | U (c) | D (b) | D (bd) | Free (m) | U (j) | N (a) | D (m) | Free (bd) | Free (b) | U (d) | D (bd) | D (bd) | Free (dk) | U (a) | D | Free (o) | U (d) | N (a) | D (dl) | Free (dl) | U (d) | D (dl) | Free (p) |
| α, deg | No spin | No spin | 74<br>41 | No spin | No spin | 92<br>72 | No spin | 68<br>52 | No spin | 71<br>58 | 70 | 75<br>47 | 78<br>58 | 89<br>55 | No spin | No spin | 87<br>30 | 96<br>60 | 77<br>56 | 72<br>57 | 73<br>60 | 77<br>60 | ---- |
| φ, deg | | | 10U<br>11D | | | 58U<br>75D | | 16U<br>9D | | 2D<br>33D | 28U<br>25D | 10U<br>17D | 17U<br>25D | 50U<br>25D | | | 38U<br>38D | 56U<br>67D | 22U<br>31D | 13U<br>7D | 20D<br>41D | 32U<br>20D | ---- |
| Ω, rps | | | 0.11 | | | 0.09 | | 0.18 | | 0.17 | 0.16 | 0.15 | 0.18 | 0.23 | | | 0.20 | 0.17 | 0.23 | 0.24 | 0.19 | 0.25 | ---- |
| V, fps | | | 182 | | | 182 | | 182 | | 190 | 182 | 177 | 185 | 190 | | | 179 | 183 | 177 | 179 | 174 | 174 | ---- |
| Turns for recovery | | | ---- | | | $^{e}\frac{1}{2}$ | | $^{h}1$ | | $^{e}\frac{1}{2}$ | $^{f}\frac{3}{4}$ | $^{f}\frac{1}{2}$ | $^{n}2$<br>$^{n}2\frac{1}{2}$ | $^{e}\frac{3}{4}$ | | | $^{e}\frac{1}{2}$ | $^{f}\frac{1}{2}$ | $^{h}1$ | $^{h}\frac{1}{2}$ | $^{e}\frac{1}{2}$ | $^{h}1\frac{1}{4}$ | ---- |

[a]Model oscillatory in roll and pitch; range of values or average value given.

[b]Two conditions possible.

[c]Model recovered by pitching and/or rolling out of the spin. Motion during recovery was extremely violent.

[d]Oscillatory spin; range of values or average value given.

[e]After recovery, model glided forward at a flat attitude for an appreciable distance before striking safety net.

[f]After recovery, model glided forward at a flat attitude for a short distance before striking safety net.

[g]After recovery, model glided forward at a flat attitude for a short distance and then nosed down into a steep dive.

[h]After recovery model nosed down into a steep dive.

[i]Model too oscillatory in pitch and roll to test completely.

[j]Model yawed in a circle of extremely large radius at a high angle of attack. Rotational velocity was low.

[k]Wandering spin.

[l]Model oscillates in pitch and wanders; appears to gallop.

[m]Model recovered of its own accord in a wide spiral glide.

[n]Model recovered in a wide spiral glide.

[o]Model went into an inverted spin after a short vertical dive.

[p]High rate of descent. Model executed one violent oscillation in pitch per turn of spin.

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CHART 12.- SPIN DATA OBTAINED WITH MODEL 12 (CONCLUDED)

| | Loading D | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | | Neutral | | | | | With | | | | |
| Elevators | U (c) | N (c) | D | Free (bd) | Free (b) | U (d) | N (d) | D (d) | Free (bd) | Free (bd) | U (d) | N (bd) | D (bq) | Free (br) | Free (bd) |
| α, deg | No spin | No spin | No spin | 57<br>41 | No spin | 73<br>21 | 85<br>48 | 49<br>39 | 73<br>50 | 52<br>37 | 75<br>63 | 84<br>55 | --- | 76<br>43 | 44 |
| ø, deg | | | | 22U<br>0 | | 21U<br>18D | 50U<br>42D | 8U<br>5D | 11U<br>7D | 1U<br>15D | 30U<br>12D | 19U<br>14D | --- | 0<br>14D | 13U<br>6D |
| Ω, rps | | | | 0.18 | | 0.13 | 0.20 | 0.19 | 0.22 | 0.21 | 0.20 | 0.22 | --- | 0.20 | 0.17 |
| V, fps | | | | 204 | | 174 | 171 | 203 | 177 | 206 | 177 | 177 | --- | 182 | 208 |
| Turns for recovery | | | | ---- | | [e]$\frac{1}{4}$ | [e]$\frac{1}{2}$ | [h]$\frac{1}{2}$ | [h]1 | [h]1 | [e]$\frac{3}{4}$ | [h]$1\frac{1}{2}$ | --- | [h]$1\frac{1}{4}$ | ---- |

| | Loading E | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | Neutral | | | | | With | | | |
| Elevators | U (a) | N (a) | D (c) | Free (c) | U (d) | N (c) | D (bd) | D (bk) | Free (j) | U (d) | N (d) | D (d) | Free (j) |
| α, deg | 95<br>47 | 81<br>65 | No spin | No spin | 98<br>68 | No spin | 93<br>64 | --- | No spin | 90<br>65 | 98<br>79 | 102<br>61 | No spin |
| ø, deg | 61U<br>48D | 35U<br>64D | | | 38D<br>48D | | 42U<br>47D | --- | | 24U<br>44D | --- | 39U<br>44D | |
| Ω, rps | 0.16 | 0.17 | | | 0.18 | | 0.22 | --- | | 0.16 | 0.13 | 0.16 | |
| V, fps | 193 | 185 | | | 182 | | 185 | --- | | 179 | 182 | 171 | |
| Turns for recovery | [e]$\frac{1}{2}$ | [e]1 | | | [e]1 | | [e]$\frac{3}{4}$ | --- | | [f]$\frac{3}{4}$ | [e]1 | [e]$\frac{1}{2}$ | |

| | Loading A, flaps down 45° | | | | | |
|---|---|---|---|---|---|---|
| Ailerons | Neutral | | | With | | |
| Elevators | D (d) | Free (bd) | Free (bs) | U | D (a) | Free (dl) |
| α, deg | 79<br>62 | 82<br>63 | ---- | ---- | 87<br>39 | 87<br>49 |
| ø, deg | 10U<br>27D | 25U<br>18D | ---- | ---- | 9U<br>9D | 3D |
| Ω, rps | 0.21 | 0.19 | ---- | ---- | 0.17 | 0.19 |
| V, fps | 179 | 179 | ---- | ---- | 179 | 179 |
| Turns for recovery | [h]$1\frac{1}{4}$ | [h]$\frac{3}{4}$ | ---- | ---- | [h]$\frac{3}{4}$ | [h]$\frac{3}{4}$ |

| | Loading A, landing gear extended | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ailerons | Neutral | | | | | | With | |
| Elevators | D (dt) | D (dt) | D (ct) | Free (dt) | Free (dt) | Free (st) | D (d) | Free (d) |
| α, deg | 72<br>57 | 66<br>41 | ---- | 60<br>41 | 50<br>37 | ---- | 61<br>46 | 65<br>52 |
| ø, deg | 15U<br>10D | 11U<br>8D | ---- | 1D | 3U | ---- | 8D | 3D |
| Ω, rps | 0.20 | 0.19 | ---- | 0.19 | 0.23 | ---- | 0.16 | 0.16 |
| V, fps | 185 | 198 | ---- | 182 | 201 | ---- | 195 | 193 |
| Turns for recovery | [h,u]$\frac{3}{4}$ | [h,u]$\frac{1}{2}$ | ---- | [h,u]$\frac{3}{4}$ | ---- | ---- | [h]$\frac{3}{4}$ | [h]$\frac{1}{2}$<br>[h]1 |

| | Loading A, landing condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | Neutral | | | | With | | |
| Elevators | D (i) | Free (d) | U (bs) | U (bd) | N (d) | Free (d) | U (d) | D (d) | Free (d) |
| α, deg | No spin | 66<br>22 | ---- | 65<br>54 | 91<br>69 | 62<br>47 | 69<br>58 | 78<br>58 | 64<br>29 |
| ø, deg | | 16U<br>2U | ---- | 12U<br>14D | 27U<br>40D | 9U<br>3D | 20U<br>15D | 15U<br>25D | 13U<br>15D |
| Ω, rps | | 0.15 | ---- | 0.14 | 0.09 | 0.16 | 0.16 | 0.16 | 0.14 |
| V, fps | | 198 | ---- | 176 | 171 | 188 | 179 | 176 | 183 |
| Turns for recovery | | [h]$\frac{1}{2}$ | ---- | [e]$\frac{1}{2}$ | [e]$\frac{1}{4}$ | [h,u]$\frac{1}{2}$ | [f]$\frac{1}{4}$ | [h,u]$\frac{1}{2}$ | [h,u]$\frac{1}{4}$ |

[a]Model oscillatory in roll and pitch, range of values or average value given.

[b]Two conditions possible.

[c]Model recovered by pitching and for rolling out of the spin. Motion during recovery was extremely violent.

[d]Oscillatory spin, range of values or average value given.

[e]After recovery, model glided forward at a flat attitude for an appreciable distance before striking safety net.

[f]After recovery, model glided forward at a flat attitude for a short distance before striking safety net.

[g]After recovery, model glided forward at a flat attitude for a short distance, and then nosed down into a steep dive.

[h]After recovery model nosed down into a steep dive.

[i]Model too oscillatory in pitch and roll to test completely.

[j]Model yawed in a circle of extremely large radius at a high angle of attack. Rotational velocity was low.

[k]Wandering spin.

[l]Model oscillates in pitch and wanders; appears to gallop.

[q]Model oscillatory in pitch and roll, too wandering to test.

[r]Model oscillatory in pitch and appears to gallop; range of values or average value given.

[s]Model spins steeply and smoothly with radius of spin too large to test.

[t]Three conditions possible.

[u]Model pitched into an inverted flat attitude after short vertical dive.

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CHART 13.- INVERTED SPINNING CHARACTERISTICS OF THOSE MODELS FOR WHICH INVERTED SPIN TESTS WERE PERFORMED

[Model loadings as shown on table II, clean condition inverted spins performed with models spinning to pilot's right, rudder full with the direction of spinning rotation, recovery attempted by reversing rudder full against the spin, no modifications on models]

| | Model 1, loading A | | | | | | | | | Model 2, loading A | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | | Neutral | | | With | | |
| Elevators | U | N | D | U | N ([a]) | D | U | N | D ([a]) | U | D | U | N | D | U ([d]) | N ([e]) | D |
| α, deg | No spin | No spin | 76 | 47 | 42 | 52 | 70 | 55 | --- | No spin | No spin | No spin | No spin | No spin | 46<br>17 | | No spin |
| φ, deg | | | 3U | 2U | 1U | 5U | 5U | 4U | --- | | | | | | 6U<br>7D | | |
| Ω, rps | | | 0.72 | 0.36 | 0.42 | 0.49 | 0.59 | 0.47 | --- | | | | | | 0.30 | | |
| V, fps | | | 158 | 227 | 235 | 173 | 175 | 193 | --- | | | | | | 229 | | |
| Turns for recovery | | | | [b] | [b] | 2 | ∞ | [c] | | | | | | | ∞ | ∞ | |

| | Model 4, loading A | | | | | | | | | Model 5, loading A | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With | | | Against | Neutral | | | With |
| Elevators | U | N | D | U | N | D | U | N | D | U ([d]) | U ([d]) | N' ([d]) | D ([d]) | U ([d]) |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | - | 55<br>66 | 51<br>58 | 54<br>62 | 50<br>61 | 49<br>57 |
| φ, deg | | | | | | | | | - | 4U<br>10D | 4U<br>0 | 5U<br>4D | 2U<br>6D | 5U<br>8D |
| Ω, rps | | | | | | | | | - | 0.33 | 0.32 | 0.35 | 0.36 | 0.33 |
| V, fps | | | | | | | | | - | 203 | 220 | 200 | 191 | 214 |
| Turns for recovery | | | | | | | | | - | 1/2 | 1/2,<br>3/4 | 1,<br>1 3/4 | [f]3/4<br>[f]3/4 | 1/2<br>1/2 |

| | Model 6, loading B | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | Neutral | | | With $\frac{1}{3}$ | With Full | | |
| Elevators | U | N | D | U | N | D | U | U | N | D |
| α, deg | No spin | No spin | No spin | No spin | No spin | No spin | No spin | 50 | 46 | |
| φ, deg | | | | | | | | 4D | 3D | |
| Ω, rps | | | | | | | | 0.46 | 0.48 | 0.50 |
| V, fps | | | | | | | | 221 | 233 | 252 |
| Turns for recovery | | | | | | | | $2\frac{1}{2}$, $2\frac{1}{2}$<br>[g]1, [g]1,<br>3/4, 3/4<br>[g]2,<br>3/4, $1\frac{1}{2}$ | 4, 4, 3<br>[g]1<br>3/4, 3/4 $\frac{1}{2}$<br>[g]3<br>$1\frac{3}{4}$, $1\frac{1}{2}$ | 3/4<br>1/2 |

| | Model 7, loading A | | | | | | | | | | | | | Model 8, Loading G | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against Full | | | Against $\frac{1}{3}$ | | Neutral | | | With $\frac{1}{3}$ | | With Full | | | Against | | | Neutral | | | With |
| Elevators | U | N | D ([j]) | $\frac{2}{3}$U | $\frac{2}{3}$D ([h]) | U ([i][k]) | N ([i][k]) | D ([n]) | $\frac{2}{3}$U ([i]) | $\frac{2}{3}$D ([h]) | U ([i]) | N ([i]) | D ([i]) | U ([n]) | N ([m]) | D ([m]) | U ([o]) | N ([m]) | D ([m]) | D ([p]) |
| α, deg | 82 | 78 | No spin | 76 | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | No spin | - | No spin | No spin | No spin |
| φ, deg | 14D | 1D | | 14D | | | | | | | | | | | | | - | | | |
| Ω, rps | 0.38 | 0.40 | | 037 | | | | | | | | | | | | | - | | | |
| V, fps | 186 | 186 | | 210 | | | | | | | | | | | | | - | | | |
| Turns for recovery | 1<br>[l] | [l] | | [l] | | | | | | | | | | | | | [q]1/4 | | | |

| | Model 10, loading A | | | Model 11, loading A | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | Neutral | With | Against | | | Neutral | | | With | | |
| Elevators | U ([d]) | N | U | U ([o]) | N ([o]) | D ([o]) | U ([r]) | N ([s]) | D ([s]) | U ([r]) | N ([r]) | D ([r]) |
| α, deg | 47 | | | - | - | - | - | 85 | 82 | - | - | - |
| φ, deg | 6U<br>6D | | | - | - | - | - | 34U<br>31D | 8U<br>18D | - | - | - |
| Ω, rps | | 0.61 | 0.58 | - | - | - | - | 0.07 | 0.07 | - | - | - |
| V, fps | approx. 250 | 194 | 250 | - | - | - | - | 121 | 121 | - | - | - |
| Turns for recovery | [f], 1-1/2<br>3 | ∞ | [f], > 3<br>[f], > 5 | | | | | [f], [t], 1/4 | [f], [t], 1/4 | | | |

| | Model 12, loading A | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ailerons | Against | | | | Neutral | | | | | | With | | | | |
| Elevators | U ([u]) | N ([u]) | D ([u]) | Free ([u]) | U ([d]) | N ([d]) | D ([v])([w]) | D ([d])([w]) | D ([w]) | Free ([d]) | U ([d]) | N ([d]) | D ([d])([x]) | D ([v])([x]) | Free ([d]) |
| α, deg | No spin | No spin | No spin | No spin | 85<br>69 | 101<br>57 | - | 86<br>55 | No spin | 78<br>47 | 75<br>59 | 78<br>67 | 73<br>51 | - | 81<br>68 |
| φ, deg | | | | | 33U<br>25D | 50U<br>54D | - | 25U<br>13D | | 45U<br>42D | 23U<br>20D | 17U<br>45D | 13U<br>14D | - | 17U<br>15D |
| Ω, rps | | | | | 0.13 | 0.18 | - | 0.18 | | 0.17 | 0.15 | 0.14 | 0.20 | - | 0.22 |
| V, fps | | | | | 176 | 182 | - | 174 | | 174 | 171 | 167 | 176 | - | 176 |
| Turns for recovery | | | | | [y] 3/4 | [y]1 | - | [f], 3/4 | | 3/4 | [y], 1/2 | [y], 1/4 | 1-1/2 | - | 1<br>1-1/2 |

[a]Model oscillatory in pitch.
[b]Model went into a steep rapid spin.
[c]Model went into spin that was oscillatory in pitch, rate of rotation, and rate of descent after rudder was reversed.
[d]Oscillatory spin; range of values or average value given.
[e]Wandering and oscillatory spin.
[f]Visual estimate.
[g]Recovery attempted by neutralization of (1) rudder and ailerons, (2) elevator and ailerons, (3) ailerons.
[h]Model pulls out in a dive, rolling about longitudinal axis.
[i]Model pulls out in stalled attitude, rolling about longitudinal body axis.
[j]Model rolls erect remaining in a stalled glide with rolling and pitching oscillations.
[k]Model remains in a glide.
[l]Model launched with rudder against spin. No spin obtained.
[m]Went erect.
[n]Model immediately rolled with ailerons into erect position, pitched into inverted position, pitched back into erect position and dived.
[o]Oscillated violently in pitch and roll.
[p]Increased rolling oscillations caused model to go into stalled glide.
[q]Came out in a steep or inverted dive and tended to pitch into flat inverted position.
[r]Initial rotation stopped; fuselage remained approximately horizontal.
[s]Oscillated in roll.
[t]Fuselage remained approximately horizontal.
[u]Model recovered by pitching and rolling out of spin; motion during recovery was extremely violent.
[v]Model too oscillatory in pitch and roll to test completely.
[w]Three conditions possible.
[x]Two conditions possible.
[y]After recovery model glided forward at a flat attitude.

CHART 14.- RESULTS OF SPIN-RECOVERY PARACHUTE TESTS FOR MODELS

[Model in clean condition except where otherwise indicated; all results are for spin rotation to pilot's right, dimensions given are full-scale]

| Model | Attitude | Parachute location | Parachute diameter (ft) | Towline length (ft) | Drag coefficient | Loading | Turns for recovery: Elevator U, Ailerons Against | U, Neutral | U, With | 2/3U, 1/3 against | 2/3U, 1/3 with | N, Neutral | N, With | D, Against | D, Neutral | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Erect | Outboard wing | 5.0 | 2.5 | 0.70 | A | ---- | ∞ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | Towline attached between pitch flap and elevon |
| | -do- | --------do-------- | -do- | 15.0 | -do- | --do--- | ---- | $1, 1\frac{1}{2}$ | ∞ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 30.0 | -do- | --do-- | ---- | $1, 1\frac{1}{2}$ | ∞ | ---- | ---- | > 3 | ∞ | ---- | ---- | Do. |
| | -do- | --------do-------- | 7.0 | 2.5 | -do- | --do-- | ---- | $\frac{3}{4}$, ∞ | ∞ | ---- | ---- | $\frac{3}{4}, 1\frac{1}{4}$ | ∞ | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 15 | -do- | --do-- | ---- | $\frac{3}{4}, 1\frac{1}{2}$ | ∞ | ---- | ---- | $1\frac{1}{4}, 2$ | ∞ | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 30 | -do- | --do-- | ---- | $\frac{1}{2}, \frac{3}{4}$ | $1\frac{1}{2}, 2$ | ---- | ---- | $\frac{1}{2}, 1\frac{1}{2}$ | ∞ | ---- | ---- | Do. |
| | -do- | --------do-------- | 8.8 | 2.5 | -do- | --do-- | ---- | $\frac{1}{2}$, ∞ | [a]3, [a]9 | ---- | ---- | $\frac{1}{2}, 1\frac{1}{2}$ | ∞ | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 15 | -do- | --do-- | ---- | $\frac{1}{2}, \frac{3}{4}$ | $1\frac{1}{4}, >2\frac{1}{2}$ | ---- | ---- | $\frac{1}{4}, 1$ | $1\frac{1}{2}, 4$ | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 30 | -do- | --do-- | ---- | $\frac{1}{2}$ | $1\frac{1}{2}$ | ---- | ---- | $\frac{1}{2}, 1\frac{1}{4}$ | $1\frac{1}{2}, 2$ | ---- | ---- | Do. |
| | -do- | Outboard wing tip | 7.0 | 10 | -do- | --do-- | ---- | $\frac{1}{2}, \frac{3}{4}$ | $1\frac{1}{2}$ | ---- | ---- | 1 | $1, 1\frac{3}{4}$ | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | -do- | 30 | -do- | --do-- | ---- | $\frac{1}{2}$ | $2\frac{1}{4}, 1\frac{3}{4}$ | ---- | ---- | $\frac{1}{2}, 1$ | $1, 1\frac{1}{4}$ | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | 5.0 | 10 | -do- | --do-- | ---- | $\frac{3}{4}, 1$ | $2\frac{1}{2}, 3\frac{1}{2}$ | ---- | ---- | $1\frac{1}{2}, >3$ | ∞ | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | -do- | 15 | -do- | --do-- | ---- | $\frac{3}{4}, 1\frac{1}{4}$ | ∞ | ---- | ---- | [a] $> 3\frac{1}{2}$ | ∞ | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | -do- | 30 | -do- | --do-- | ---- | $\frac{1}{2}, 1\frac{1}{4}$ | 2, >[a]3 | ---- | ---- | 1, > 2 | ∞ | ---- | ---- | ---------------------------------- |
| 4 | -do- | Outboard wing tip | 4.0 | 19.50 | -do- | E | ---- | ---- | $3, 3\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | 25-percent semispan slats extended |
| | -do- | --------do-------- | -do- | 9.75 | -do- | --do-- | ---- | ---- | $3\frac{1}{2}, 4$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | 5.33 | 19.50 | -do- | --do-- | ---- | ---- | $2\frac{1}{4}, 3\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 9.75 | -do- | --do-- | ---- | ---- | $2\frac{3}{4}, 3\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | 6.67 | 19.50 | -do- | --do-- | ---- | ---- | $1\frac{3}{4}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | -do- | 9.75 | -do- | --do-- | ---- | ---- | $\frac{3}{4}, 1\frac{1}{4}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | 8.0 | -do- | -do- | --do-- | ---- | ---- | $1\frac{1}{4}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | Inverted | --------do-------- | 6.67 | 19.50 | -do- | --do-- | $1\frac{1}{4}, 1\frac{3}{4}$ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | 8.0 | 19.50 | -do- | --do-- | $1, 1\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | Erect | --------do-------- | 5.60 | -do- | -do- | D [a] | ---- | ---- | $>4, >4\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | 6.67 | -do- | -do- | --do-- | ---- | $1\frac{1}{2}, 2\frac{1}{4}$ | $1\frac{3}{4}, 2\frac{1}{4}$ | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | Inverted | --------do-------- | -do- | -do- | -do- | --do-- | ---- | ---- | 3 | ---- | ---- | ---- | ---- | ---- | ---- | Do. |
| | -do- | --------do-------- | 8.0 | -do- | -do- | --do-- | ---- | ---- | $2\frac{1}{4}, 2\frac{3}{4}$ | ---- | ---- | $1\frac{3}{4}$ | ---- | ---- | ---- | Do. |
| 5 | Erect | --------do-------- | 4.24 | 25 | 0.83 | A | ---- | $\frac{1}{2}$ | ---- | 1 | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | Parachutes at both wing tips | 4.39 | -do- | -do- | --do-- | ---- | ---- | ---- | 1, >2 | ---- | ---- | ---- | ---- | ---- | Two parachutes opened simultaneously |
| | -do- | --------do-------- | 7.31 | -do- | 0.70 | --do-- | ---- | ---- | ---- | $\frac{1}{2}, >2\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | 8.77 | -do- | -do- | --do-- | ---- | $\frac{1}{4}, \frac{1}{2}$ | ---- | $\frac{1}{4}, \frac{3}{4}$ | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| 6 | Erect | Tail cone | 8 | 13.4 | 0.7 | A | ---- | ---- | $2, 2\frac{1}{2}, 4, >8$ | ---- | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | 10 | -do- | -do- | --do-- | ---- | ---- | $1, 1\frac{1}{2}, 2\frac{1}{2}, 2\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | 11.7 | -do- | -do- | --do-- | ---- | ---- | $1, 1, 1, 1\frac{1}{2}$ | ---- | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | Outboard wing tip | 3.3 | 7.9 | -do- | --do-- | ---- | ---- | >8, >9 | ---- | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | 5.0 | -do- | -do- | --do-- | ---- | ---- | $2, 2\frac{1}{2}, >3$ | ---- | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |
| | -do- | --------do-------- | 6.2 | -do- | -do- | --do-- | ---- | ---- | $1\frac{1}{4}, 1\frac{1}{4}, 1\text{-}3/4$ | ---- | ---- | ---- | ---- | ---- | ---- | ---------------------------------- |

NACA

CHART 14.- RESULTS OF SPIN-RECOVERY PARACHUTE TESTS FOR MODELS - Concluded

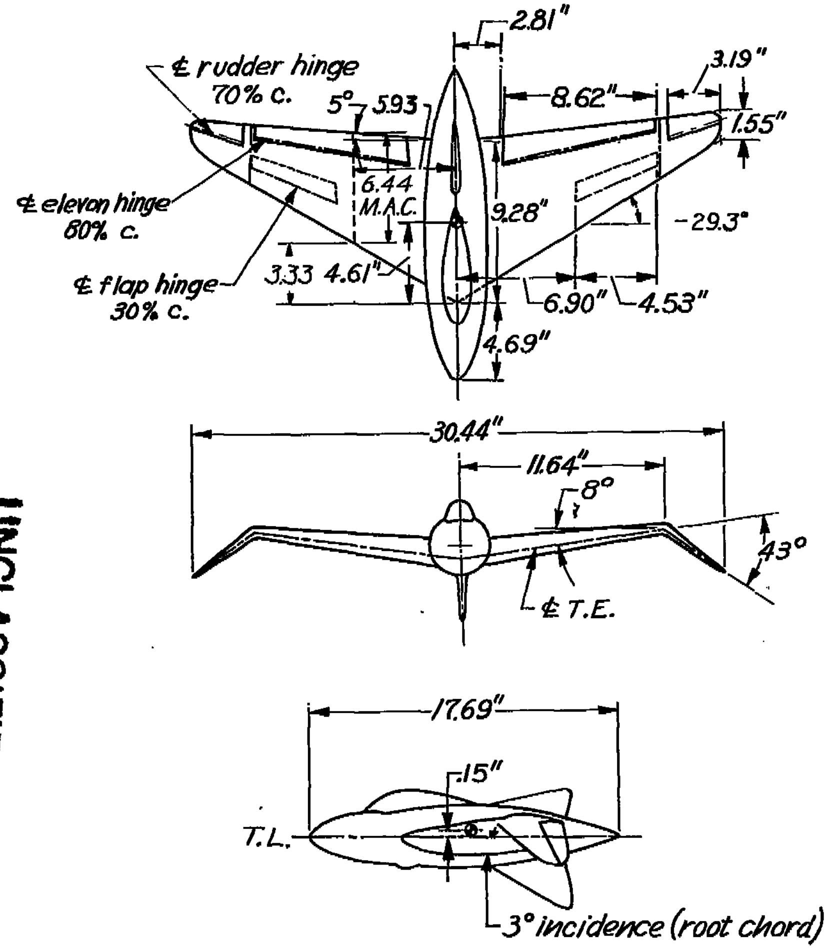
| Model | Attitude | Parachute location | Parachute diameter (ft) | Towline length (ft) | Drag coefficient | Loading | Turns for recovery | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Elevator | | | | | | | | | |
| | | | | | | | U | | | 2/3U | | N | | D | | |
| | | | | | | | Ailerons | | | | | | | | | |
| | | | | | | | Against | Neutral | With | 1/3 against | 1/3 with | Neutral | With | Against | Neutral | |
| | Erect | Tail cone | 3.6 | 27 | 0.70 | A | ----- | $\frac{1}{2}$ | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $x/\bar{c} = 0.14$ |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $2\frac{1}{2}, 2\frac{3}{4}$ | Do. |
| | -do- | --------do------- | 4.5 | -do- | -do- | --do-- | ----- | $\frac{3}{4}$, 1 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $1\frac{1}{4}, 1\frac{1}{2}$ | Do. |
| | -do- | --------do------- | 5.5 | -do- | -do- | G | ----- | 1, 2 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 1, $2\frac{3}{4}$ | Do. |
| 8 | -do- | --------do------- | 7.1 | -do- | -do- | --do-- | ----- | $\frac{1}{4}, \frac{3}{4}$ | ----- | ----- | ----- | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $1\frac{1}{4}$, 2 | Do. |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | $\frac{1}{2}$ | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $x/\bar{c} = 0.19$ |
| | -do- | --------do------- | -do- | 13.5 | -do- | --do-- | ----- | $\frac{1}{4}$ | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $x/\bar{c} = 0.14$ |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 1, $1\frac{3}{4}$ | Do. |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | $\infty$ | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $x/\bar{c} = 0.19$ |
| | -do- | --------do------- | -do- | -do- | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | $\frac{1}{4}, \frac{3}{4}$ | Do. |
| | -do- | Arresting gear mast (aft) | 13.3 | 30 | 0.70 | A | ----- | ----- | ----- | 2 | $2\frac{1}{2}, 3\frac{1}{4}$ | ----- | $\infty$ | ----- | >3 | ------------------------------- |
| | -do- | --------do------- | 16.0 | 30 | -do- | --do-- | >7 | ----- | ----- | 1-3/4, >4-1/2 | 2, $2\frac{3}{4}$ | ----- | 2, $\infty$ | ----- | ----- | ------------------------------- |
| | -do- | --------do------- | -do- | 23 | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | $\infty$ | ----- | ----- | ------------------------------- |
| | -do- | --------do------- | -do- | 15 | -do- | --do-- | >3 | ----- | ----- | ----- | ----- | ----- | $\infty$ | ----- | ----- | ------------------------------- |
| | -do- | --------do------- | 20 | 30 | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | 4, $\infty$ | ----- | ----- | ------------------------------- |
| | -do- | --------do------- | 20 | 15 | -do- | --do-- | ----- | ----- | ----- | ----- | ----- | ----- | 3, 4 | ----- | ----- | ------------------------------- |
| | -do- | Arresting gear mast and outboard end of wing | b6.9 c13.3 | 30 Q | -do- | --do-- | ----- | ----- | ----- | ----- | $2\frac{3}{4}, 4\frac{3}{4}$ | ----- | ----- | ----- | ----- | Two parachutes ~ wing tip parachute attached at c/4 |
| | -do- | --------do------- | b11.7 c6.9 | -do- -do- | -do- | --do-- | ----- | ----- | ----- | ----- | 3, $3\frac{3}{4}$ | ----- | ----- | ----- | ----- | Do. |
| 10 | -do- | --------do------- | b-do- c8.0 | -do- -do- | -do- | --do-- | ----- | ----- | ----- | ----- | $2\frac{1}{2}, 3\frac{1}{4}$ | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | b-do- c10.6 | -do- -do- | -do- | --do-- | ----- | ----- | ----- | ----- | > $2\frac{1}{2}$ | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | b13.3 c6.9 | -do- -do- | -do- | --do-- | ----- | ----- | ----- | ----- | $1\frac{3}{4}, 2\frac{3}{4}$ | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | b-do- c-do- | -do- 8.0 | -do- | --do-- | ----- | ----- | ----- | $1\frac{1}{2}, 1\frac{3}{4}$ | ----- | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | b-do- c8.0 | -do- 0 | -do- | --do-- | ----- | ----- | ----- | ----- | 1, $1\frac{3}{4}$ | ----- | ----- | ----- | ----- | Do. |
| | -do- | --------do------- | b-do- c-do- | -do- 3 | -do- | --do-- | ----- | ----- | ----- | 1, $1\frac{3}{4}$ | $1\frac{1}{4}, 1\frac{1}{2}$ | ----- | $5\frac{1}{2}$, 8 | ----- | ----- | Do. |
| | -do- | --------do------- | b-do- c11.2 | -do- 8 | ----- | ------- | ----- | ----- | ----- | ----- | 1, 2 | ----- | ----- | ----- | ----- | Do. |

[a]Visual estimate.

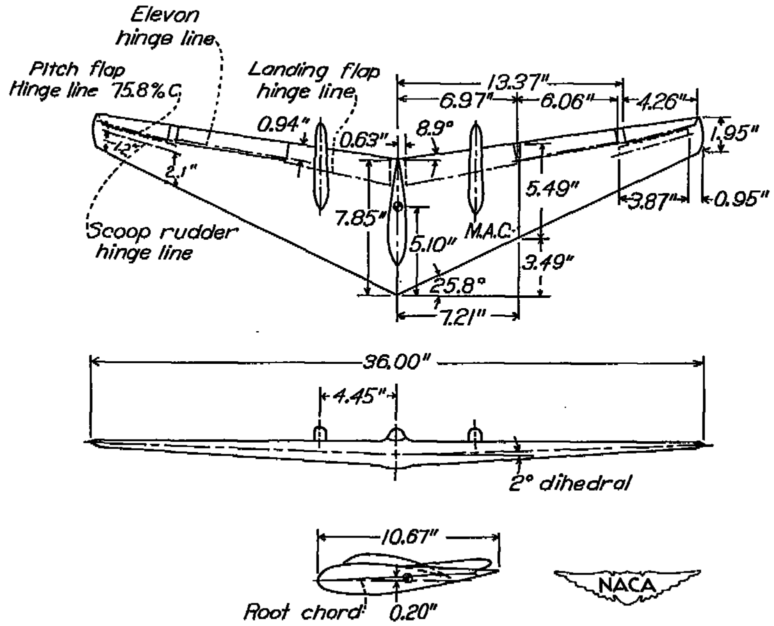
[b]Attached to arresting gear mast.

[c]Attached to outboard wing tip at the c/4 line.

NACA

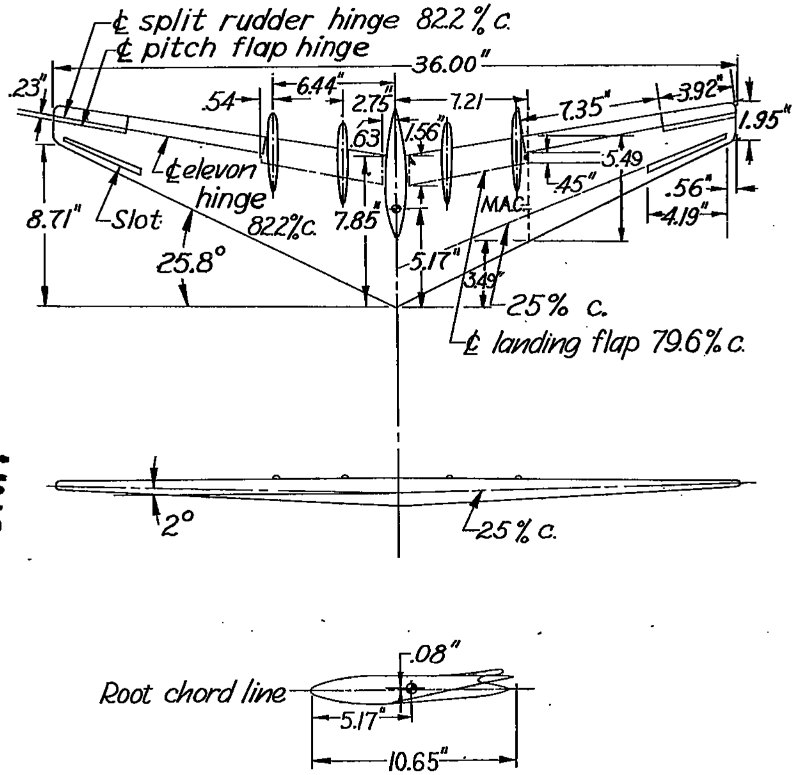



(a) Model 1.

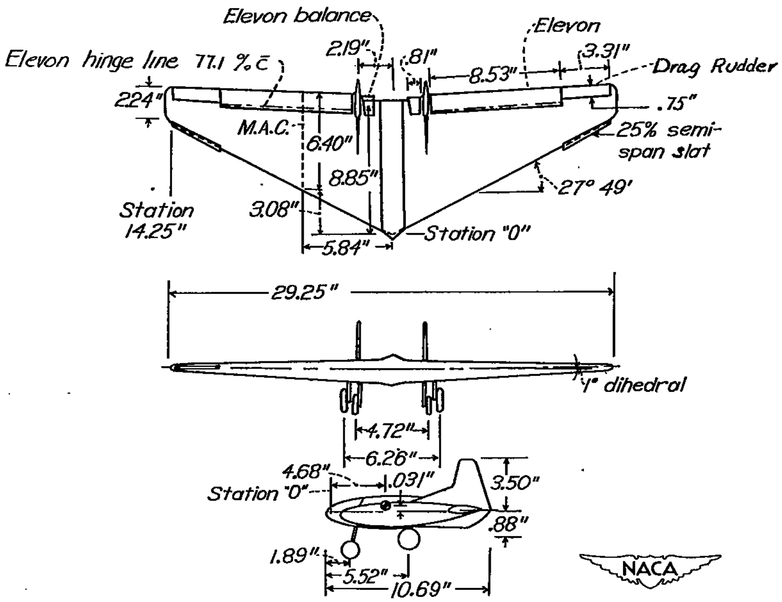



(b) Model 2.

Figure 1.- Three-view drawings of models as tested.

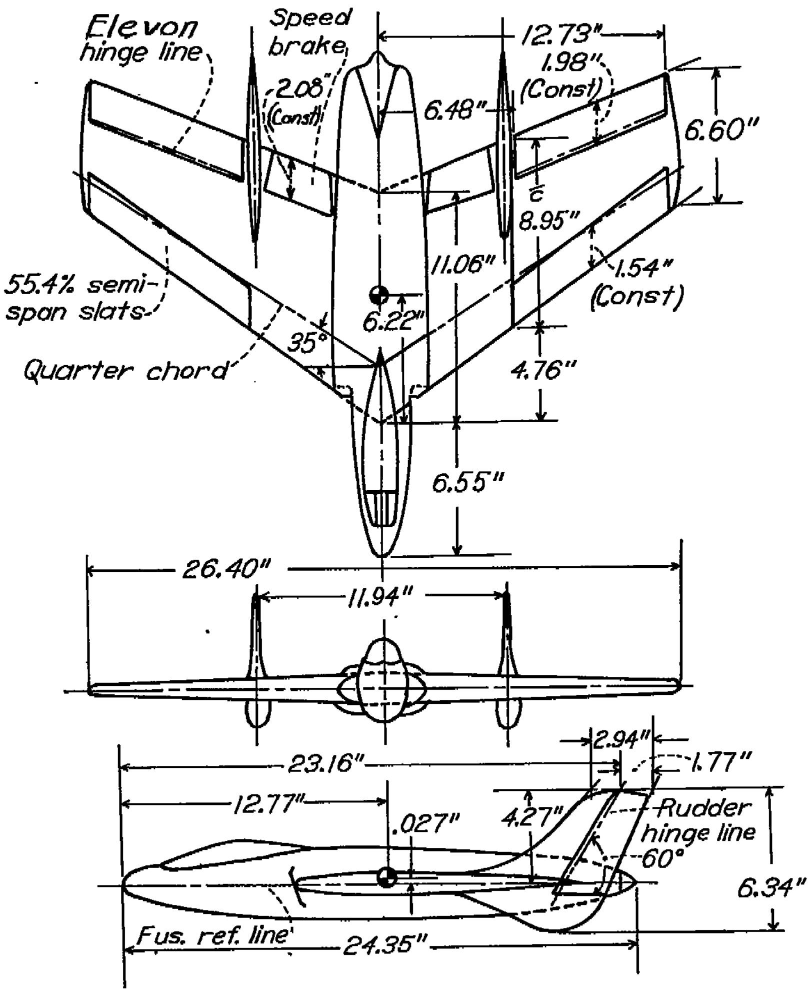



(c) Model 3.

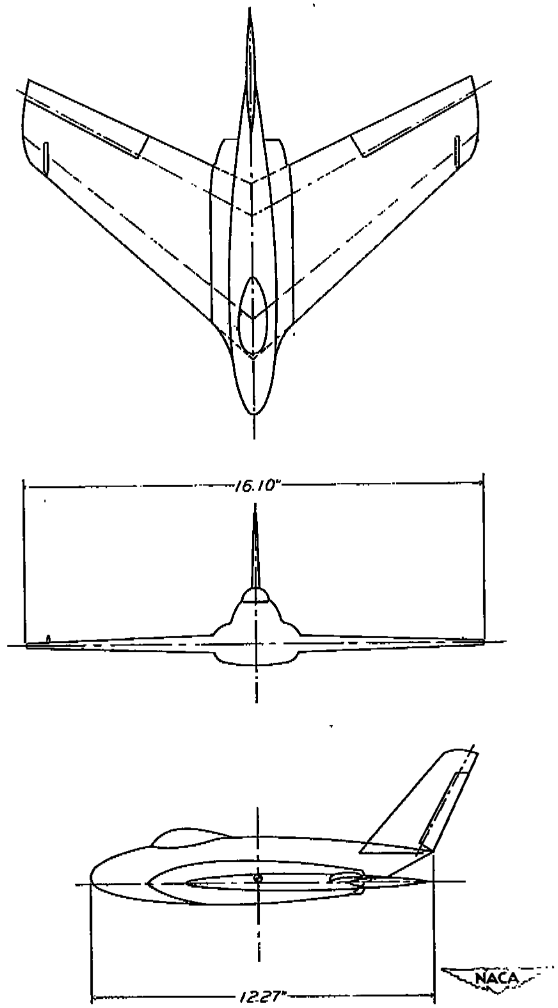



(d) Model 4.

Figure 1.- Continued.



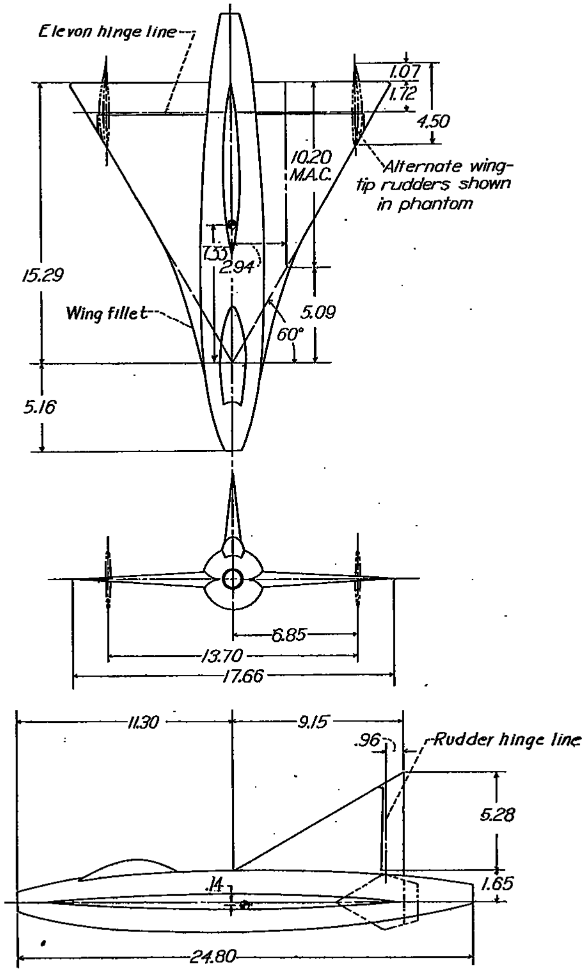

(e) Model 5.



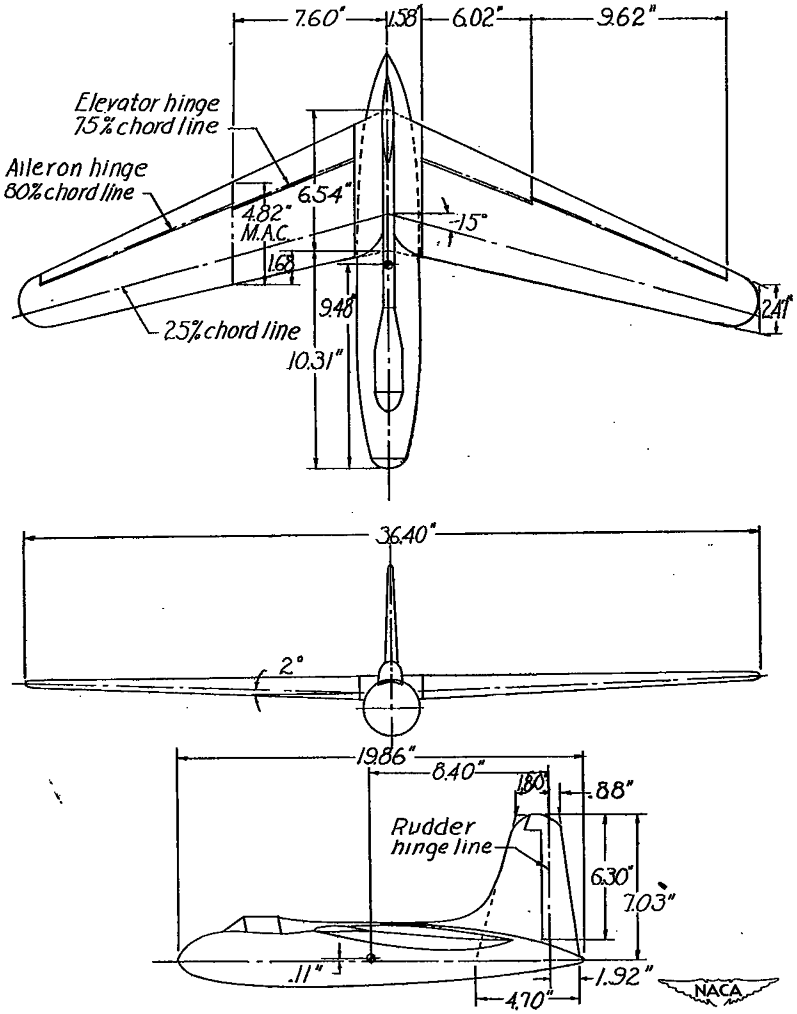

(f) Model 6.

Figure 1.- Continued.

UNCLASSIFIED

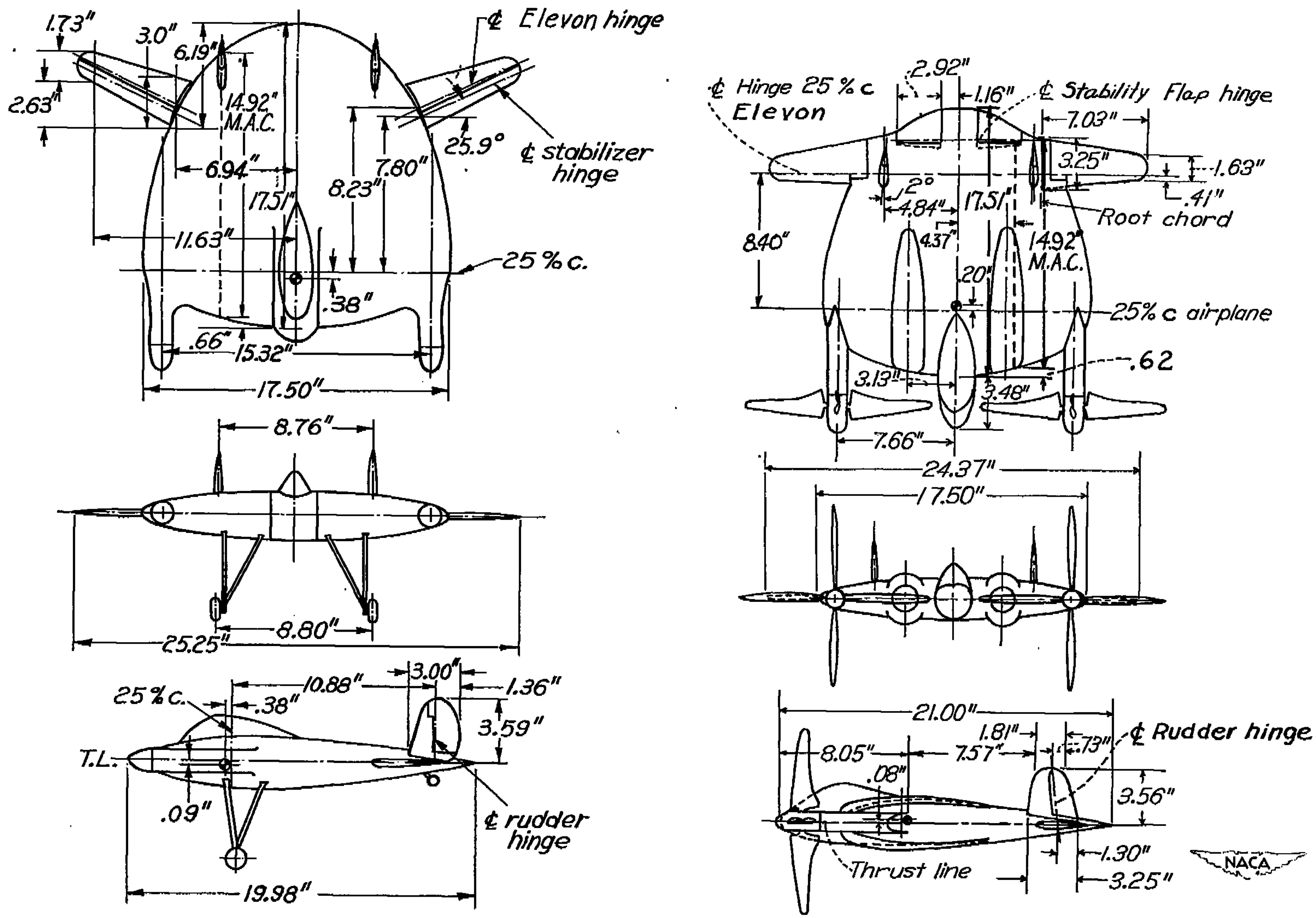



(g) Model 7.




(h) Model 8.

Figure 1.- Continued.

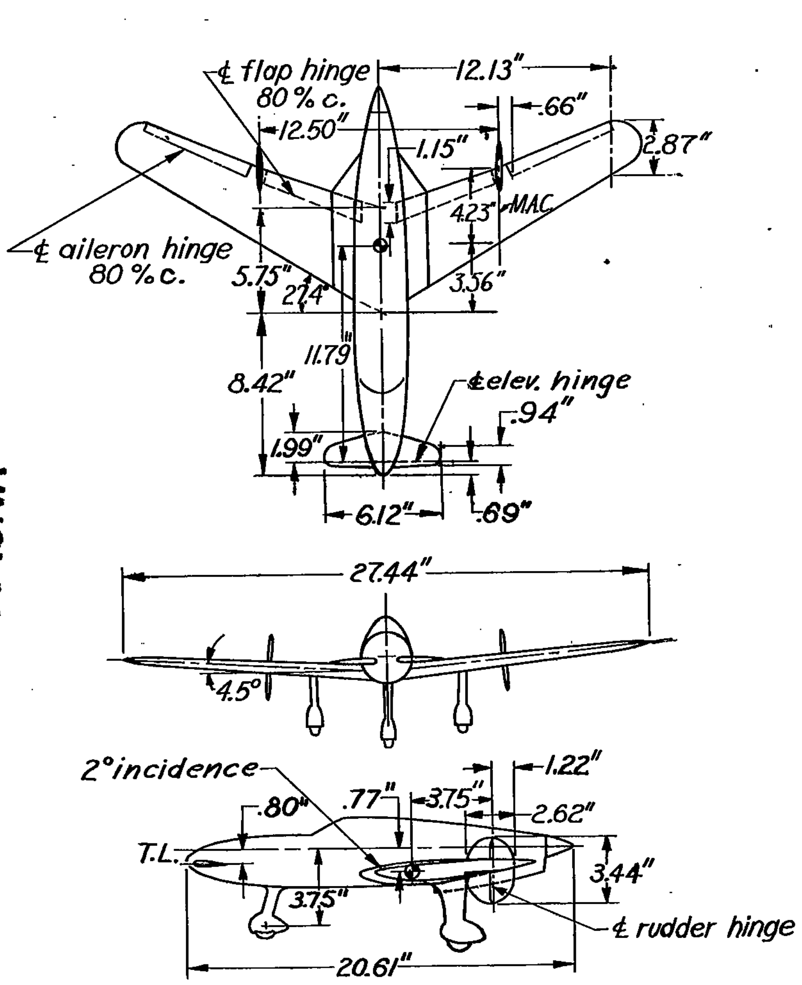



(i) Model 9.

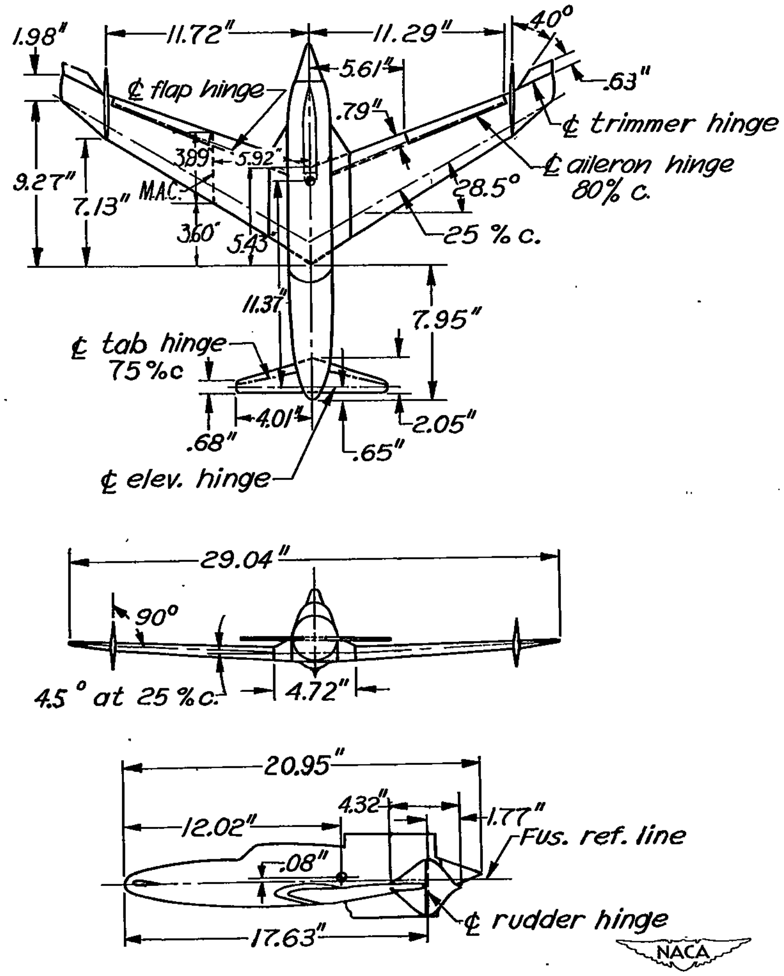
(j) Model 10.

Figure 1.- Continued.

UNCLASSIFIED




(k) Model 11.




(l) Model 12.

Figure 1.- Concluded.

UNCLASSIFIED

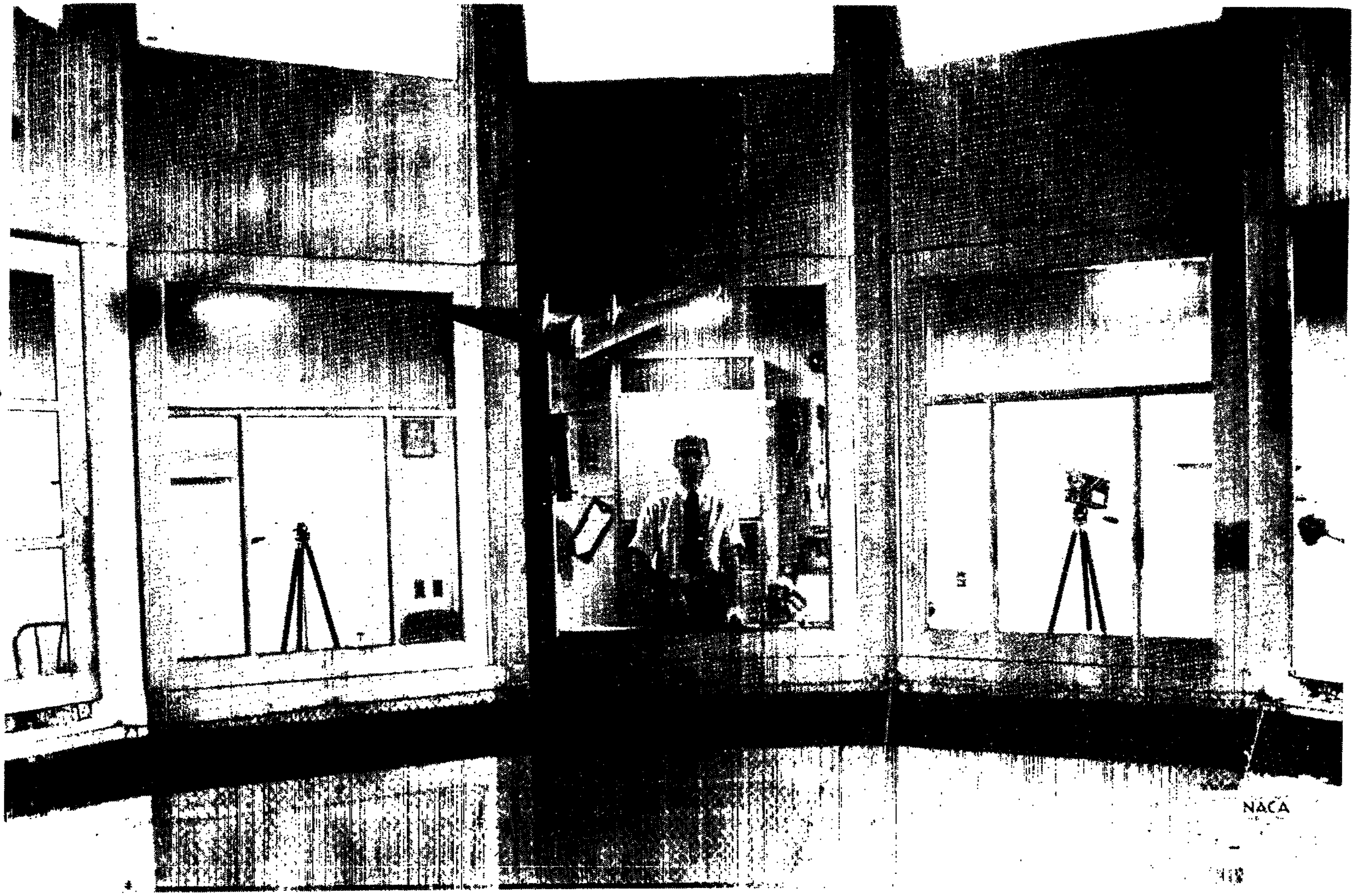
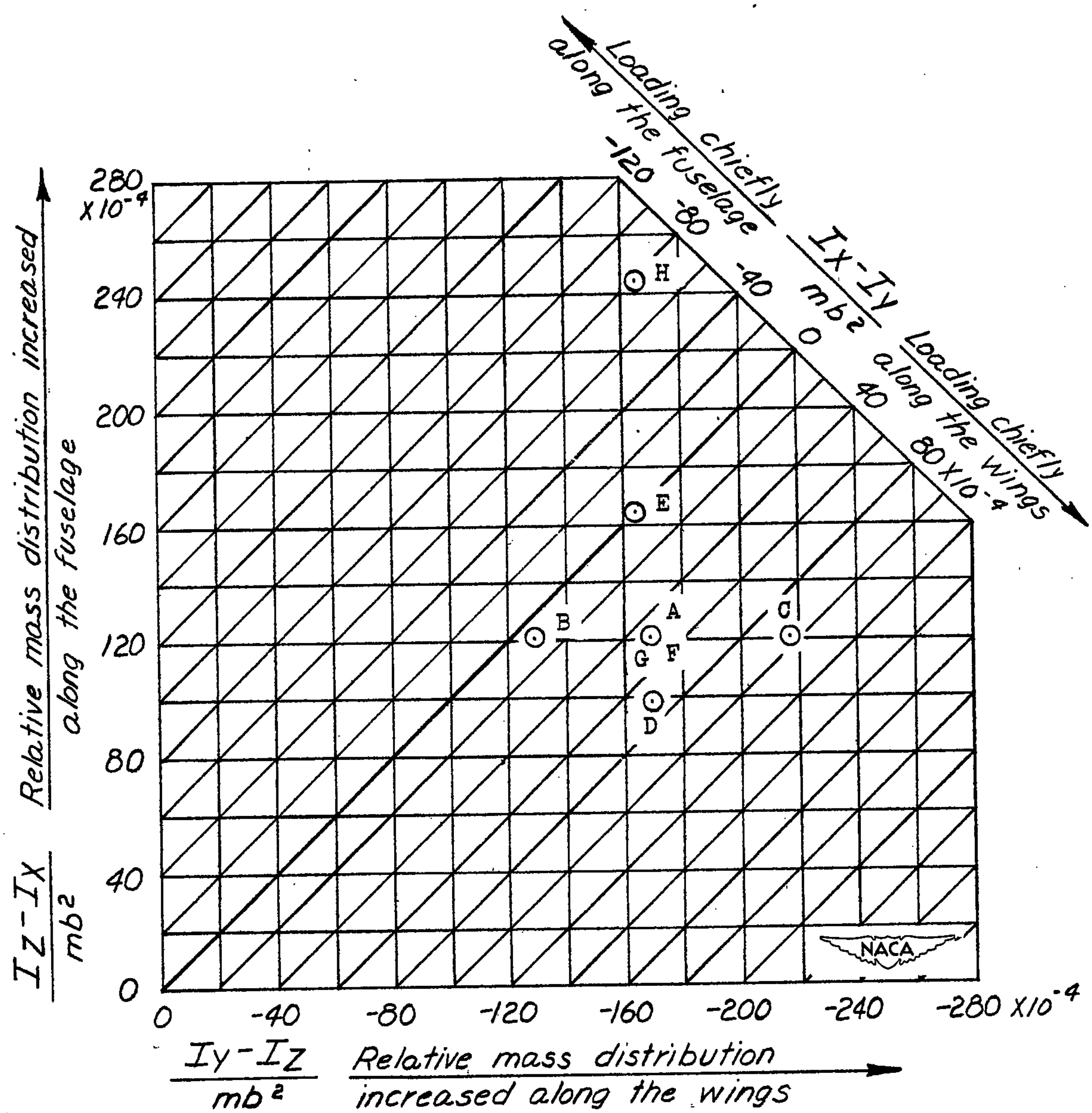
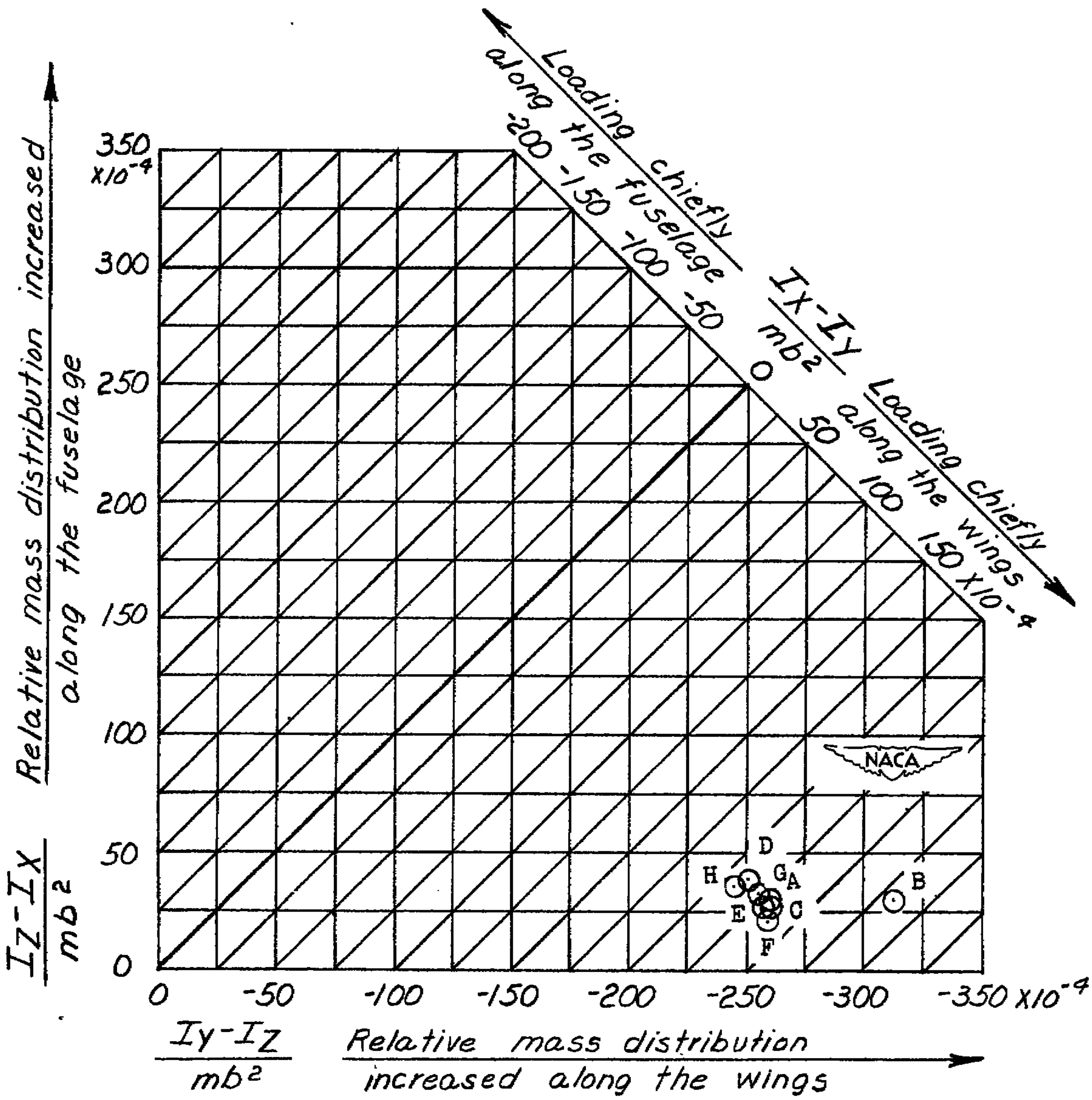



Figure 2.- Photograph of model 2 spinning in the Langley 20-foot free-spinning tunnel.



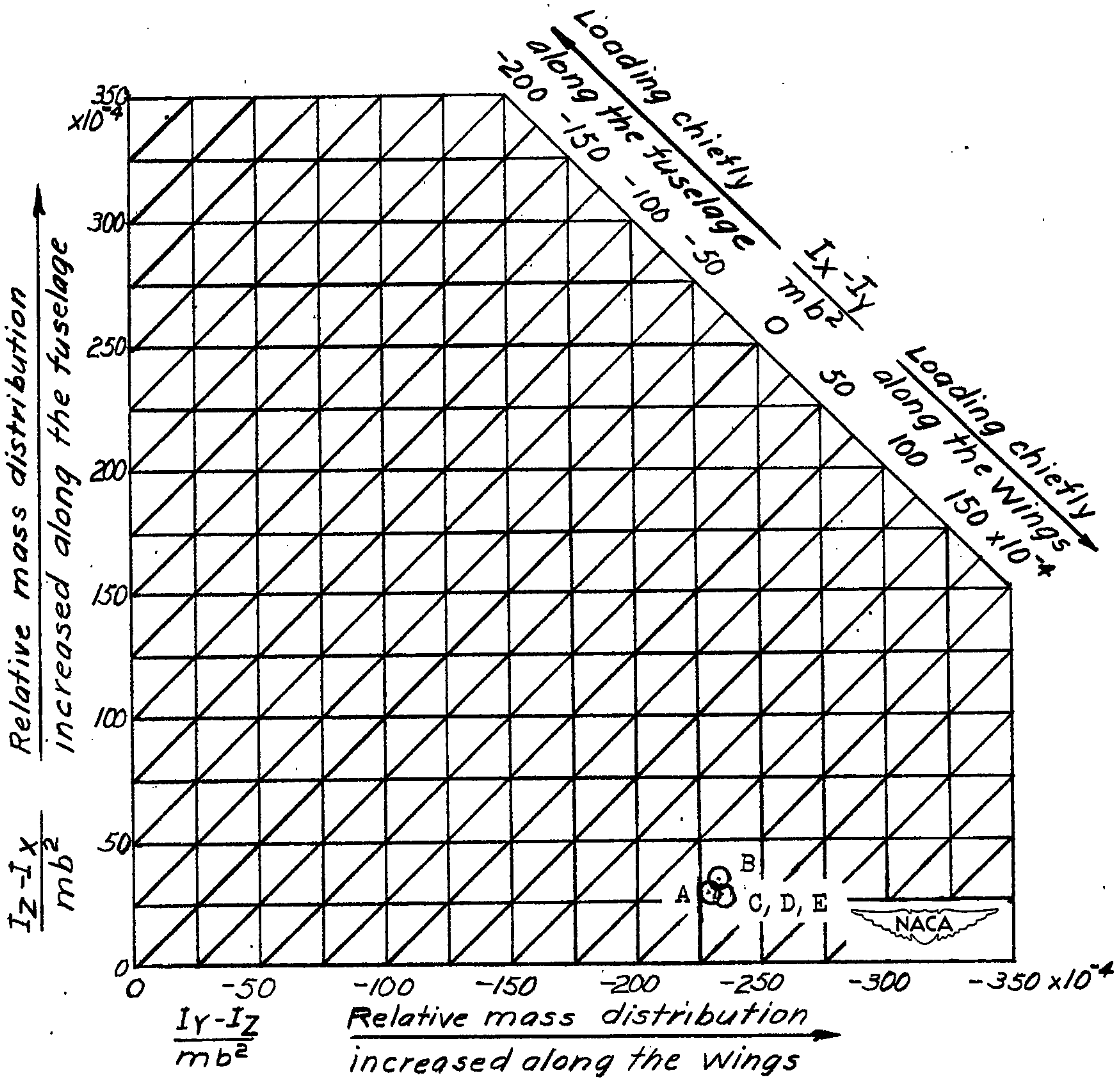

(a) Model 1.

Figure 3.- Mass parameters for loadings tested on models. (Loadings found in table II.)



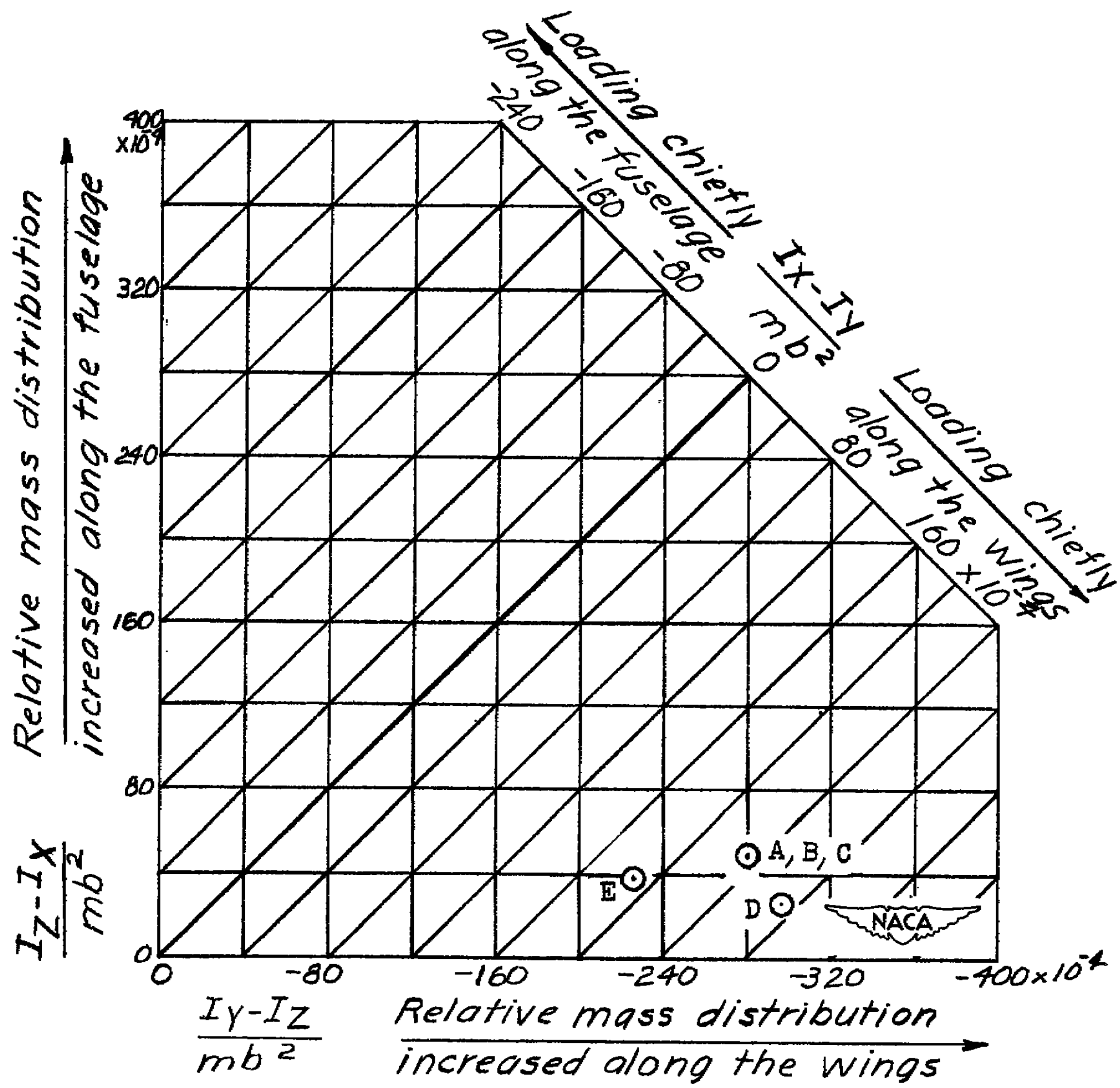

(b) Model 2.

Figure 3.- Continued.



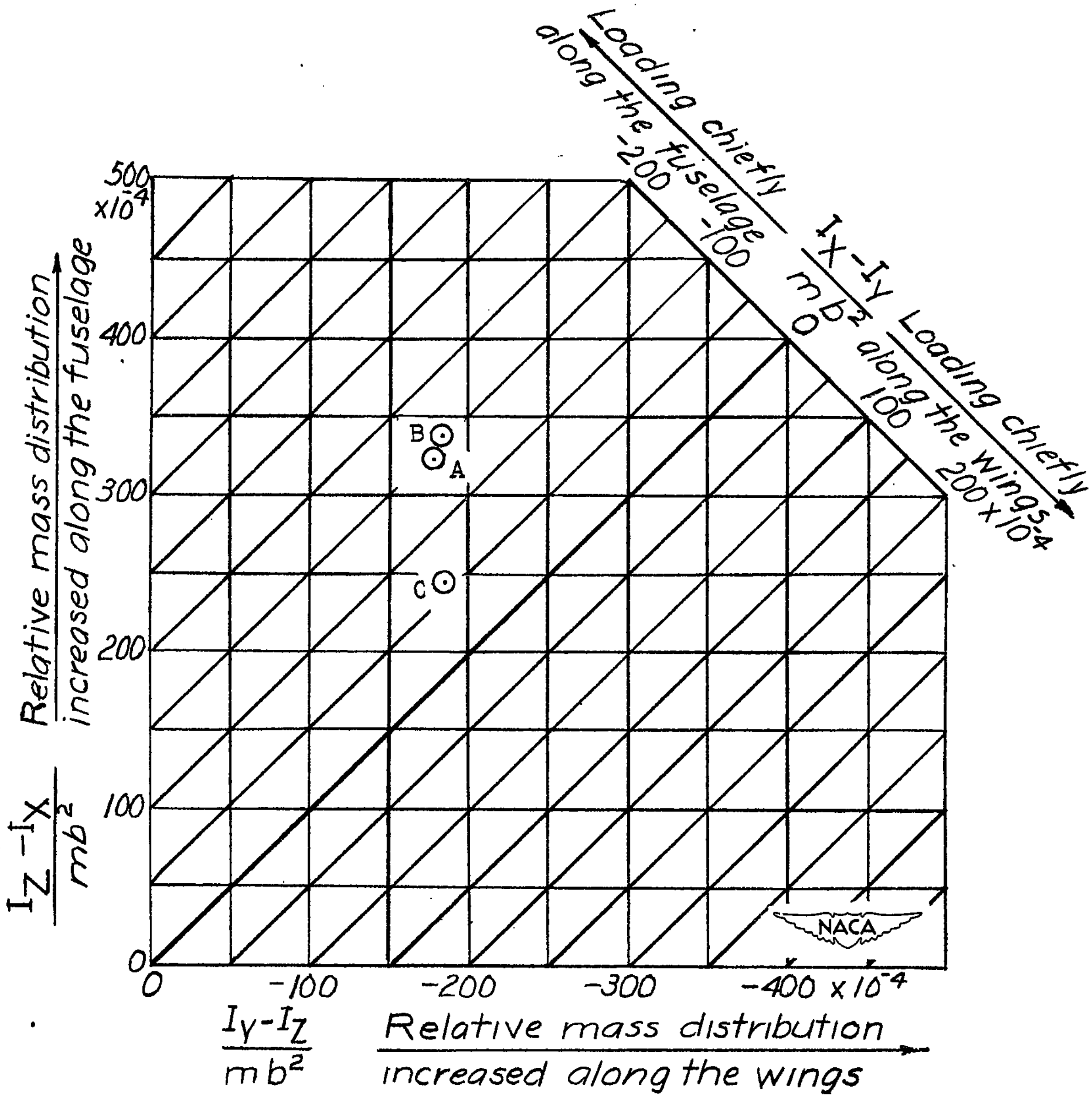

(c) Model 3.

Figure 3.- Continued.



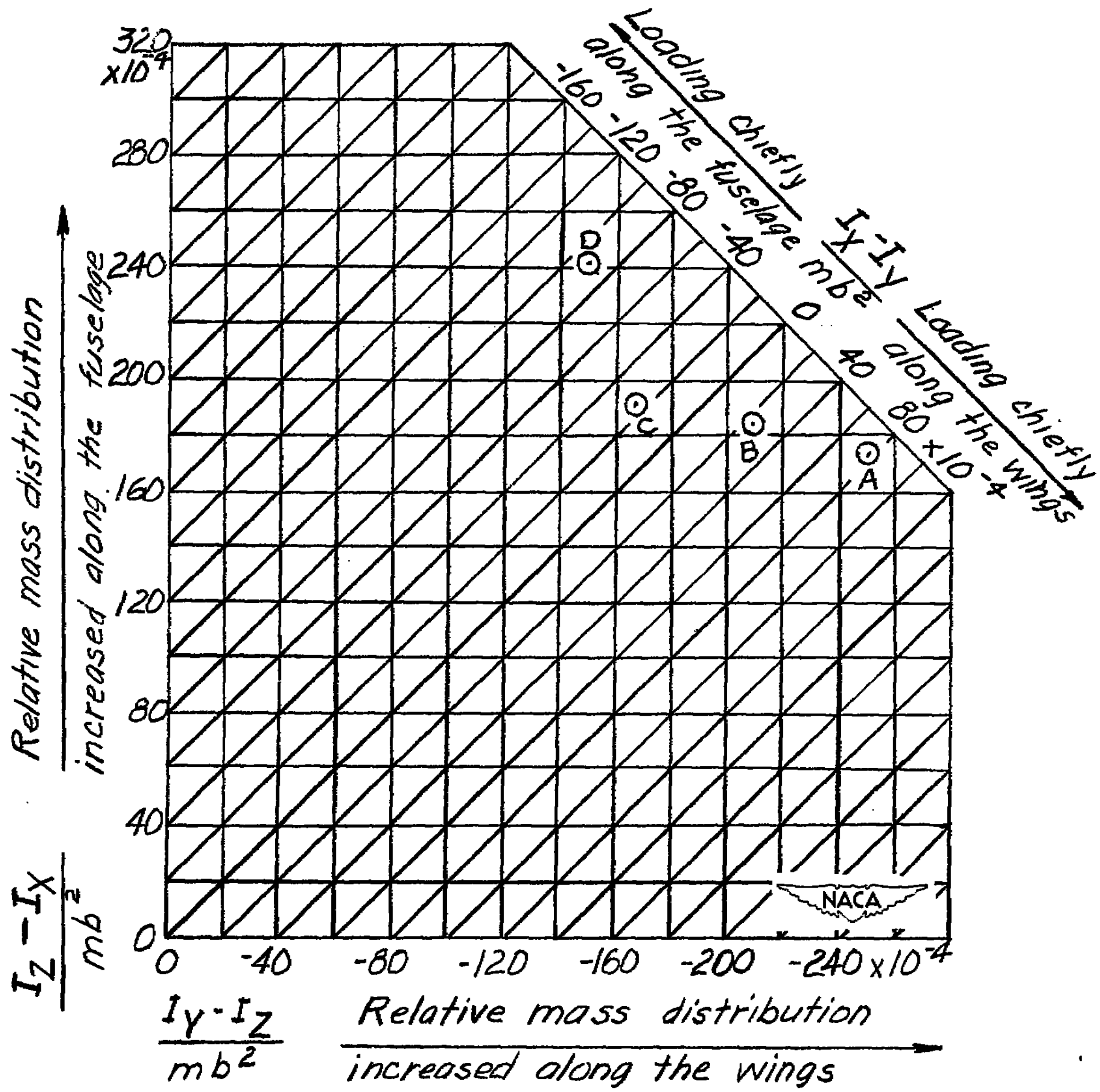

(d) Model 4.

Figure 3.- Continued.



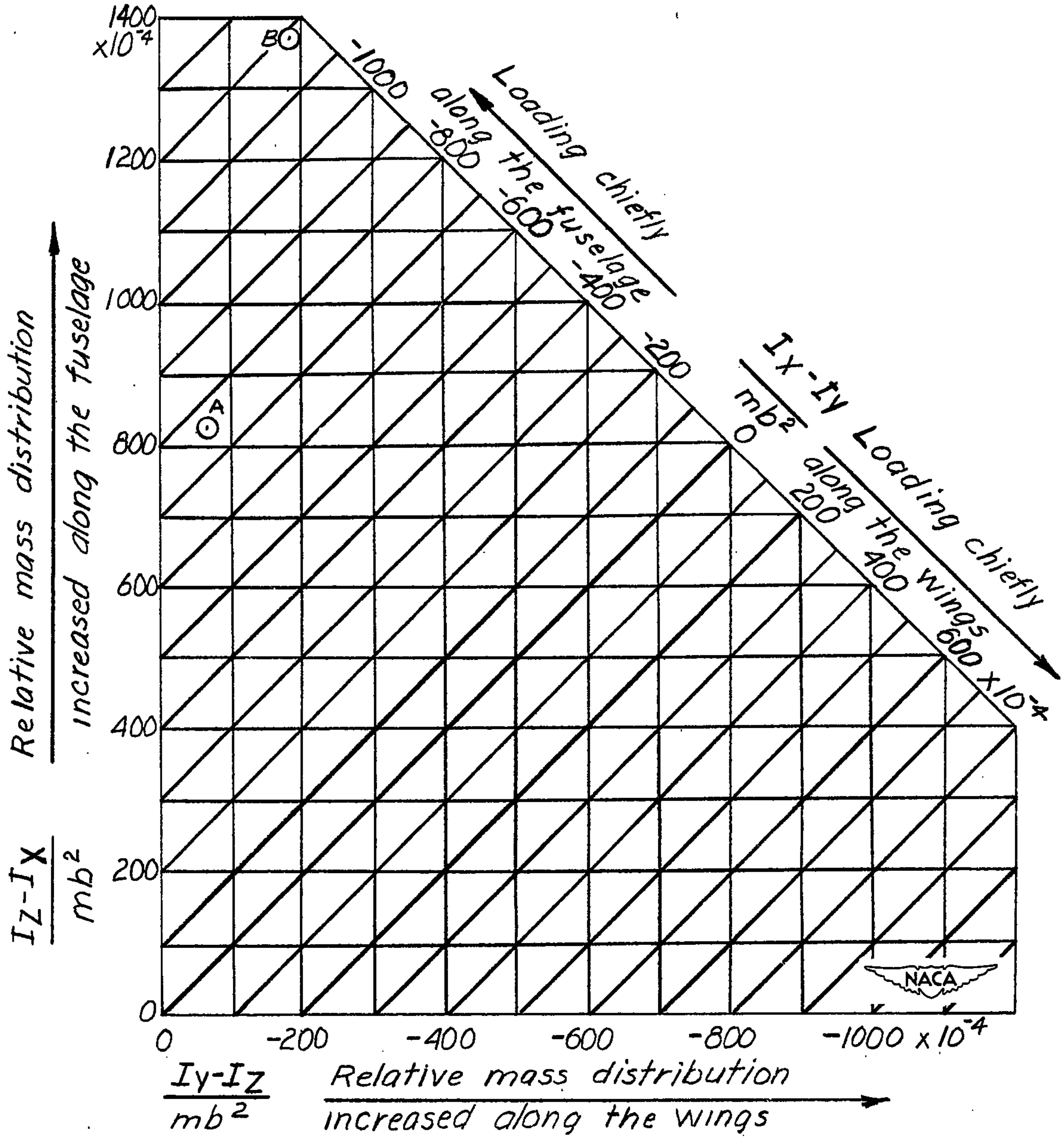

(e) Model 5.

Figure 3.- Continued.



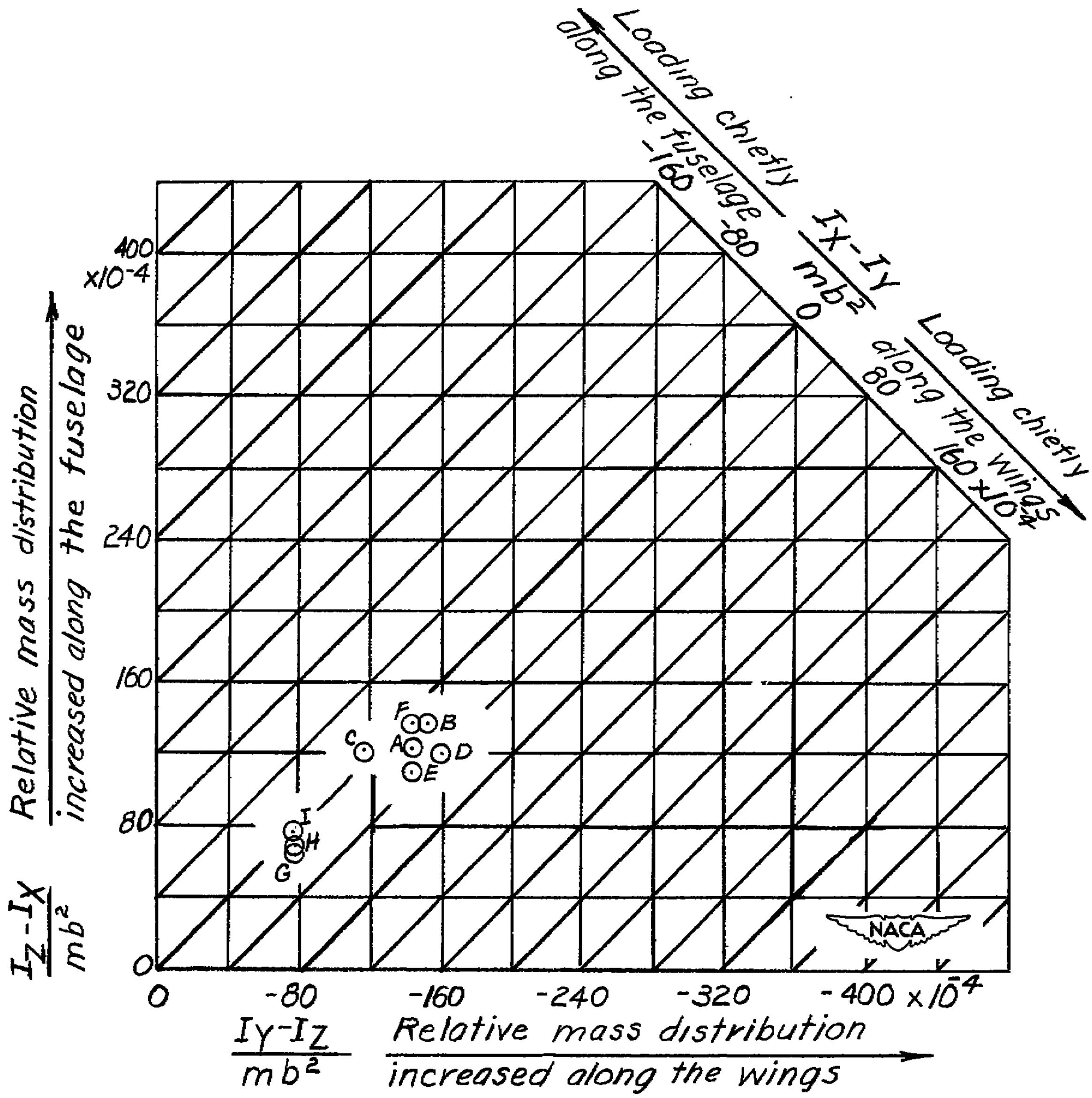

(f) Model 6.

Figure 3.- Continued.



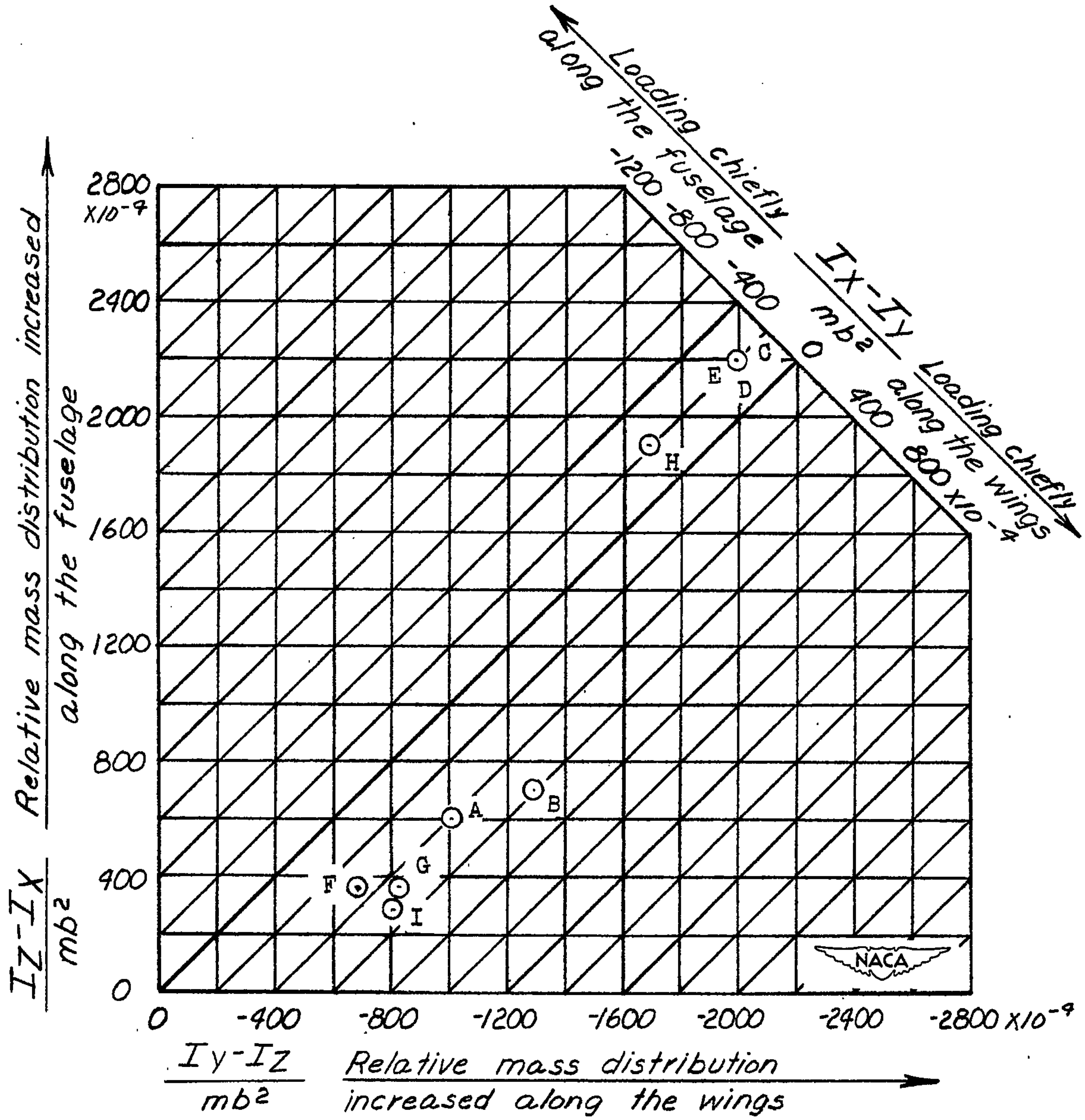

(g) Model 7.

Figure 3.- Continued.



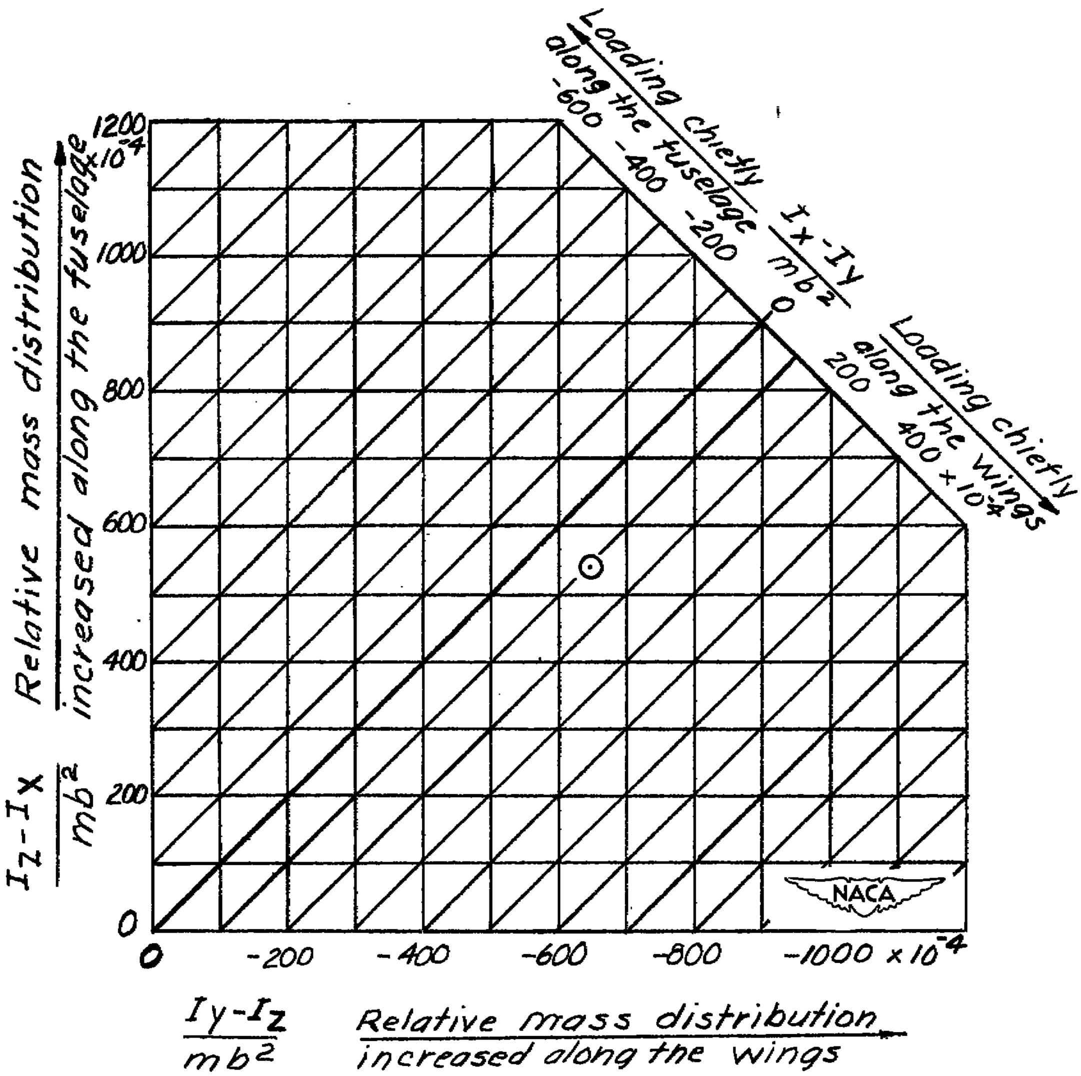

(h) Model 8.

Figure 3.- Continued.



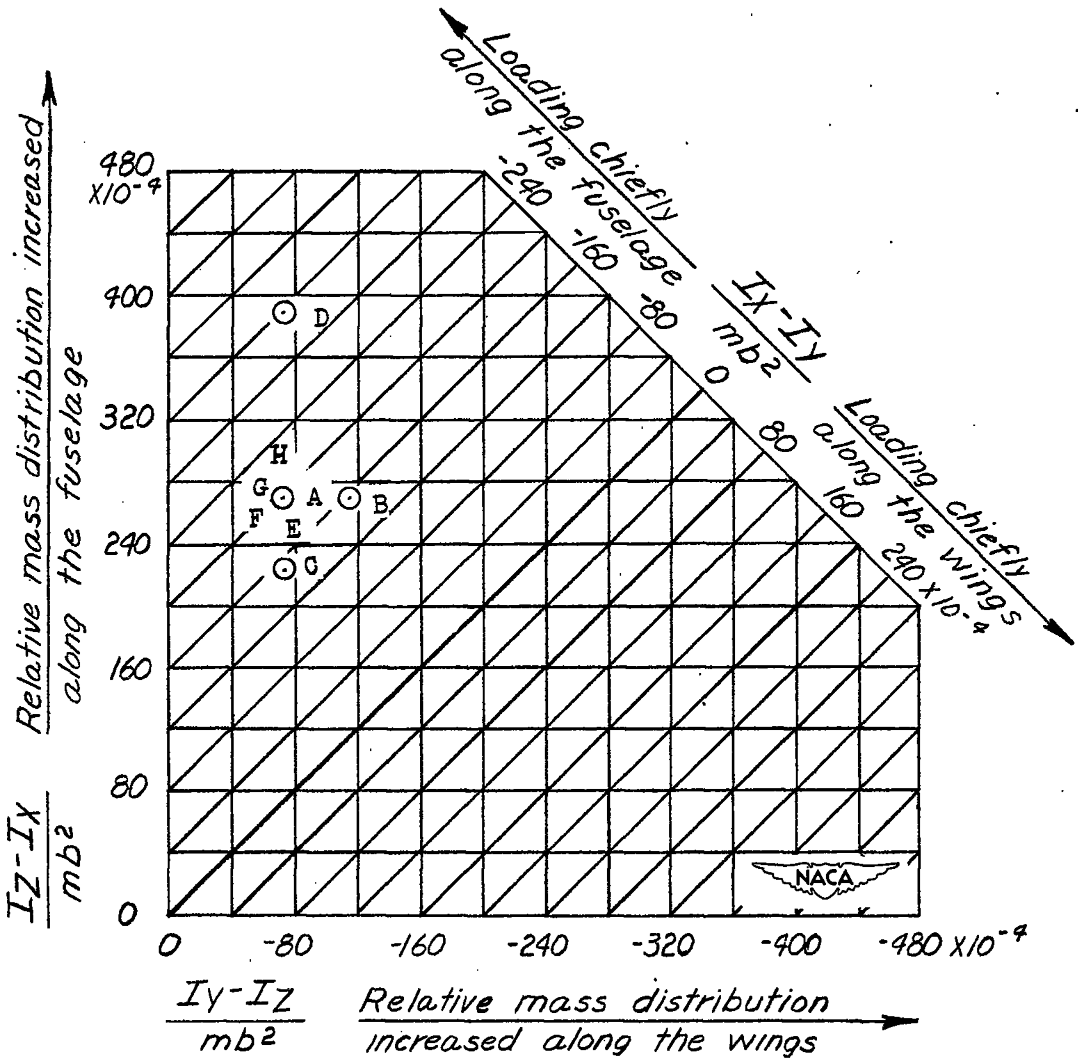

(i) Model 9.

Figure 3.- Continued.



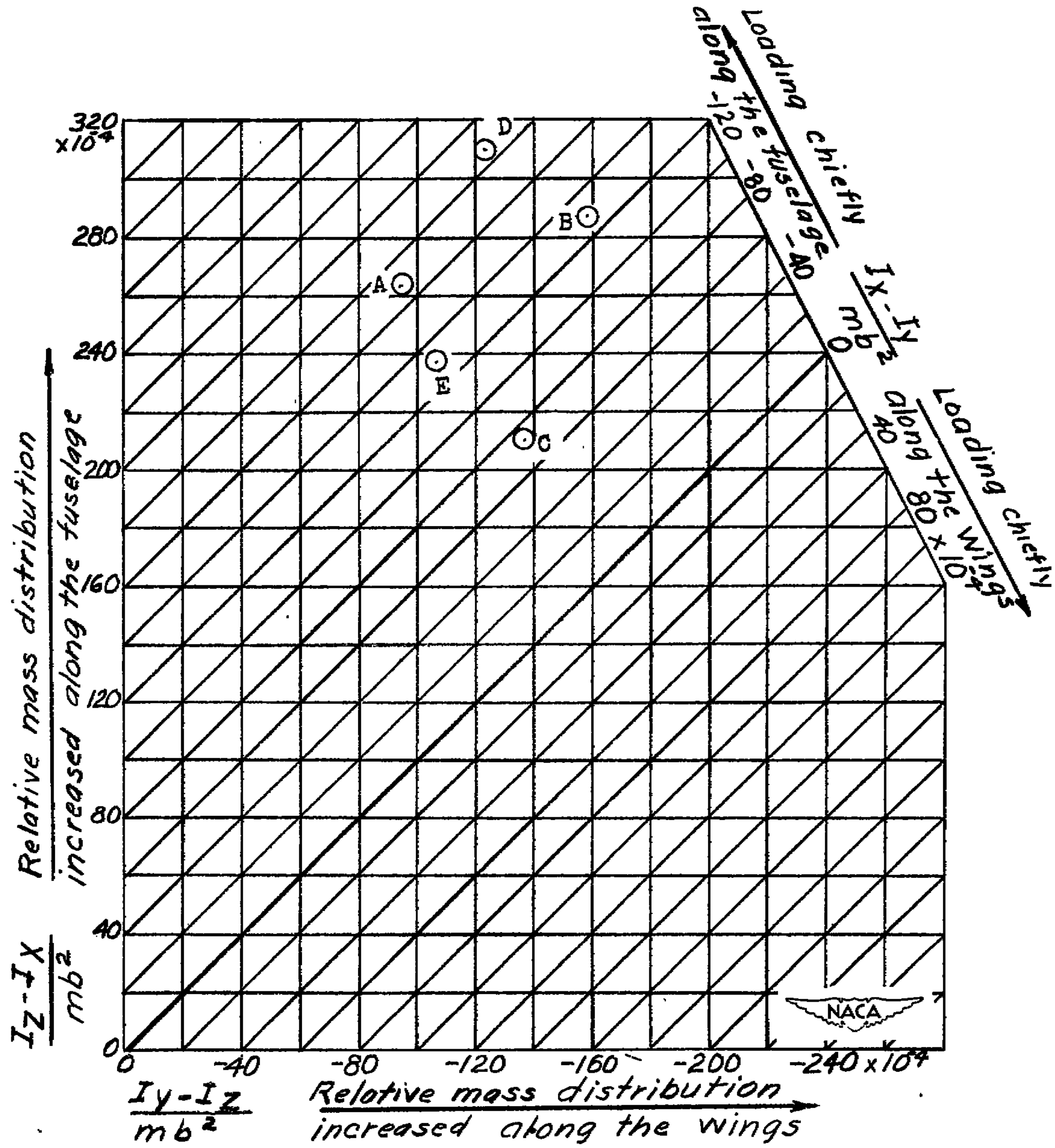

(j) Model 10.

Figure 3.- Continued.




(k) Model 11.

Figure 3.- Continued.




(*l*) Model 12.

Figure 3.- Concluded.

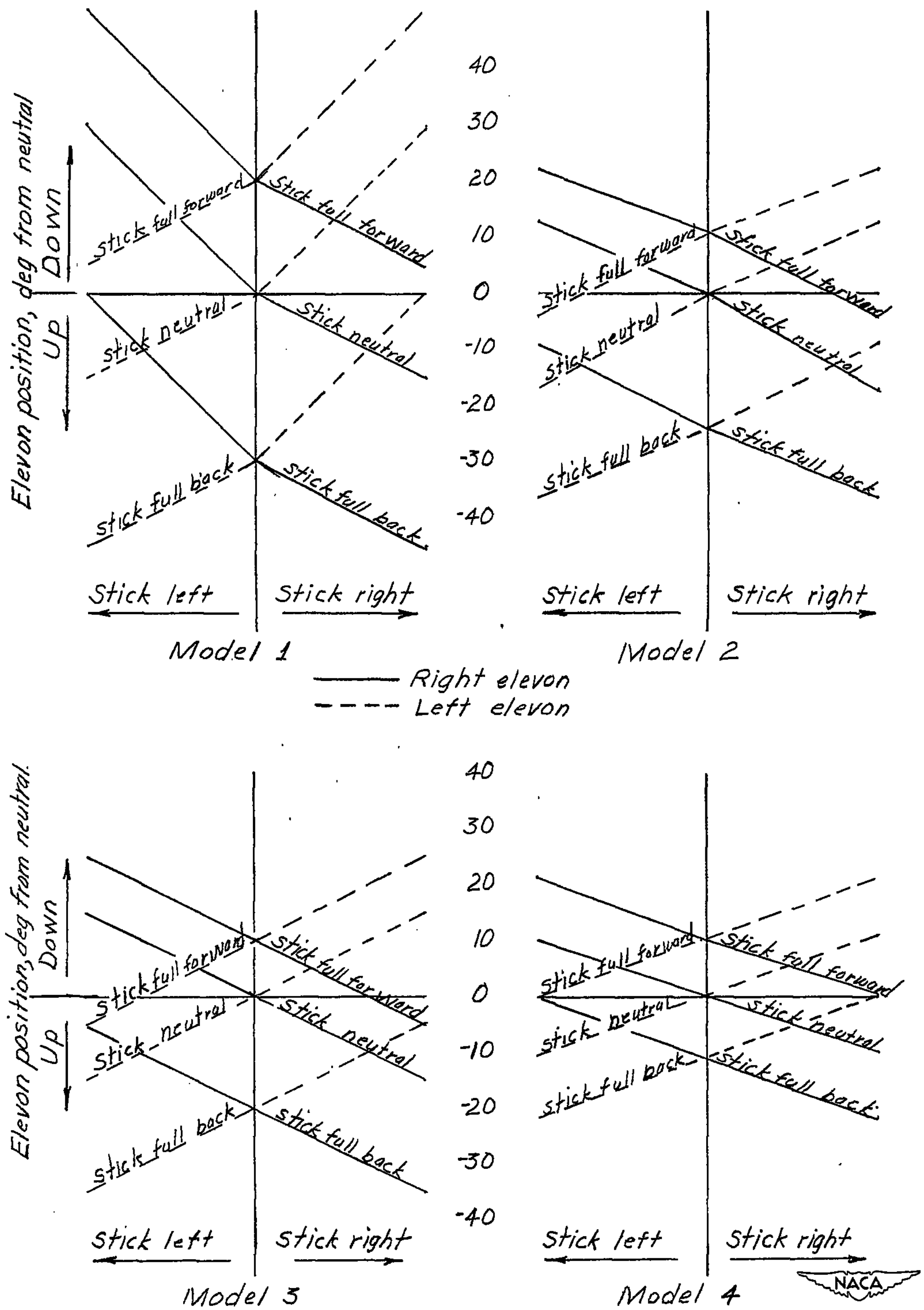



Figure 4.- Combination elevator-aileron (elevon) deflections for the models tested.

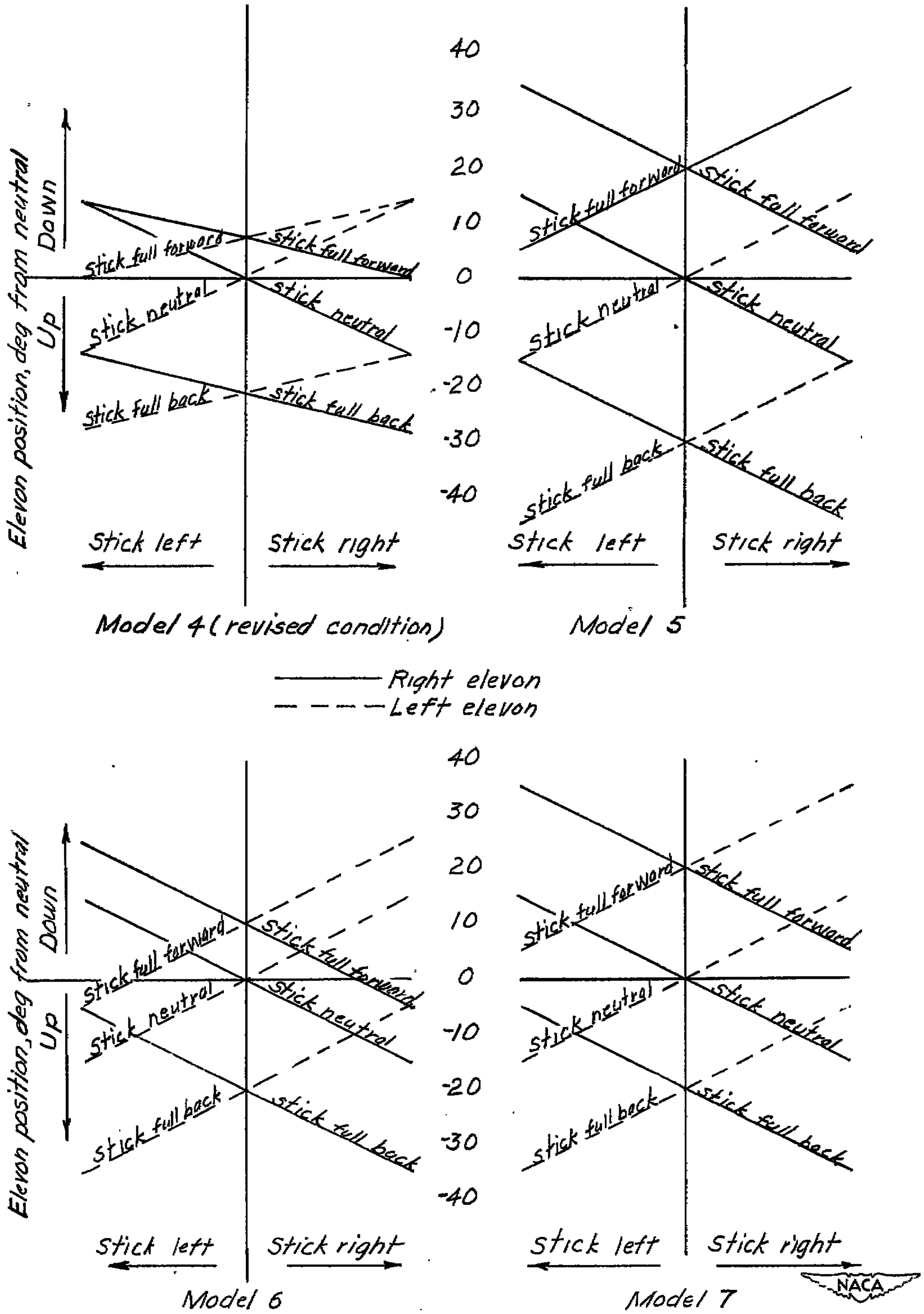



Figure 4.- Continued.

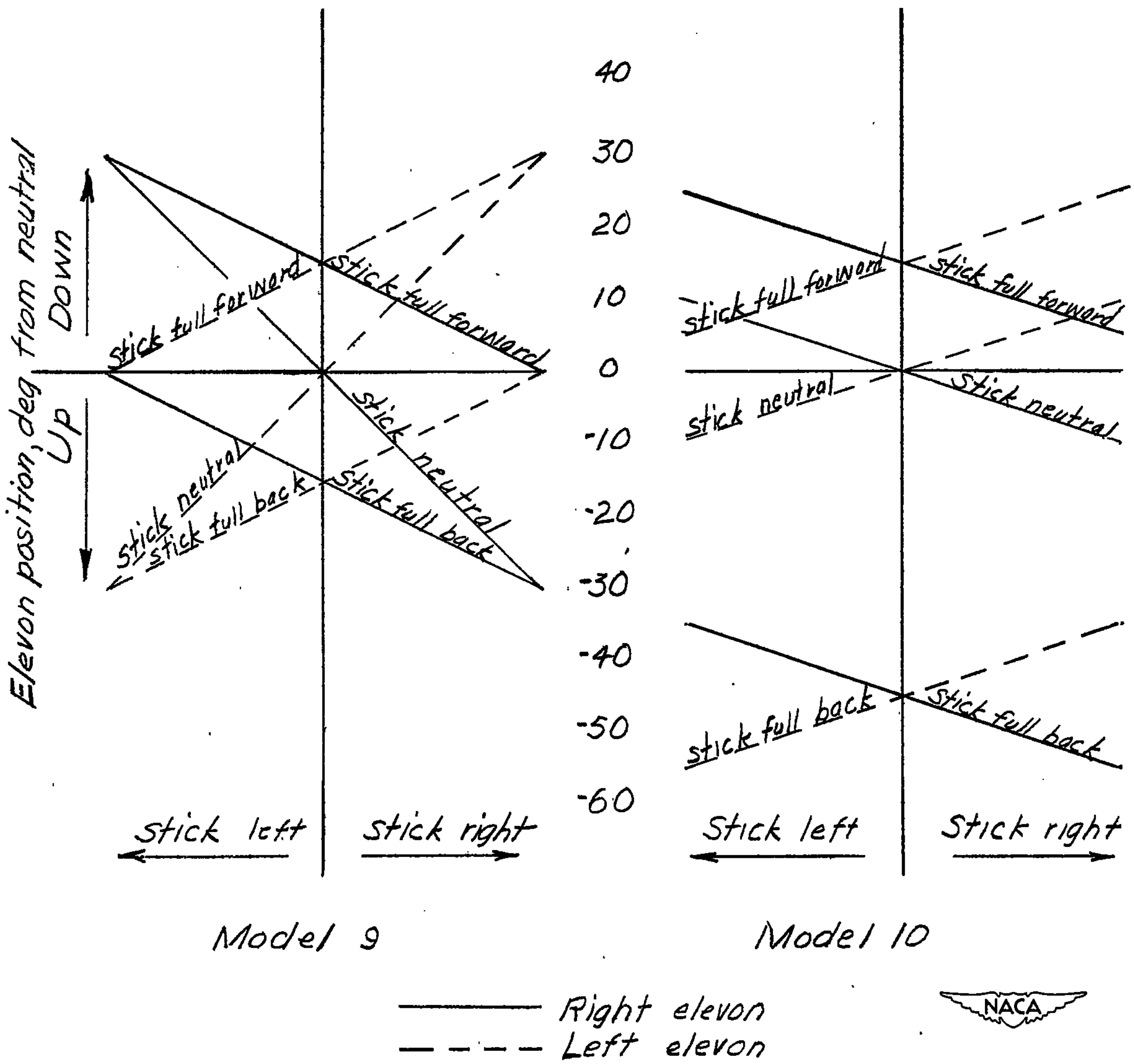
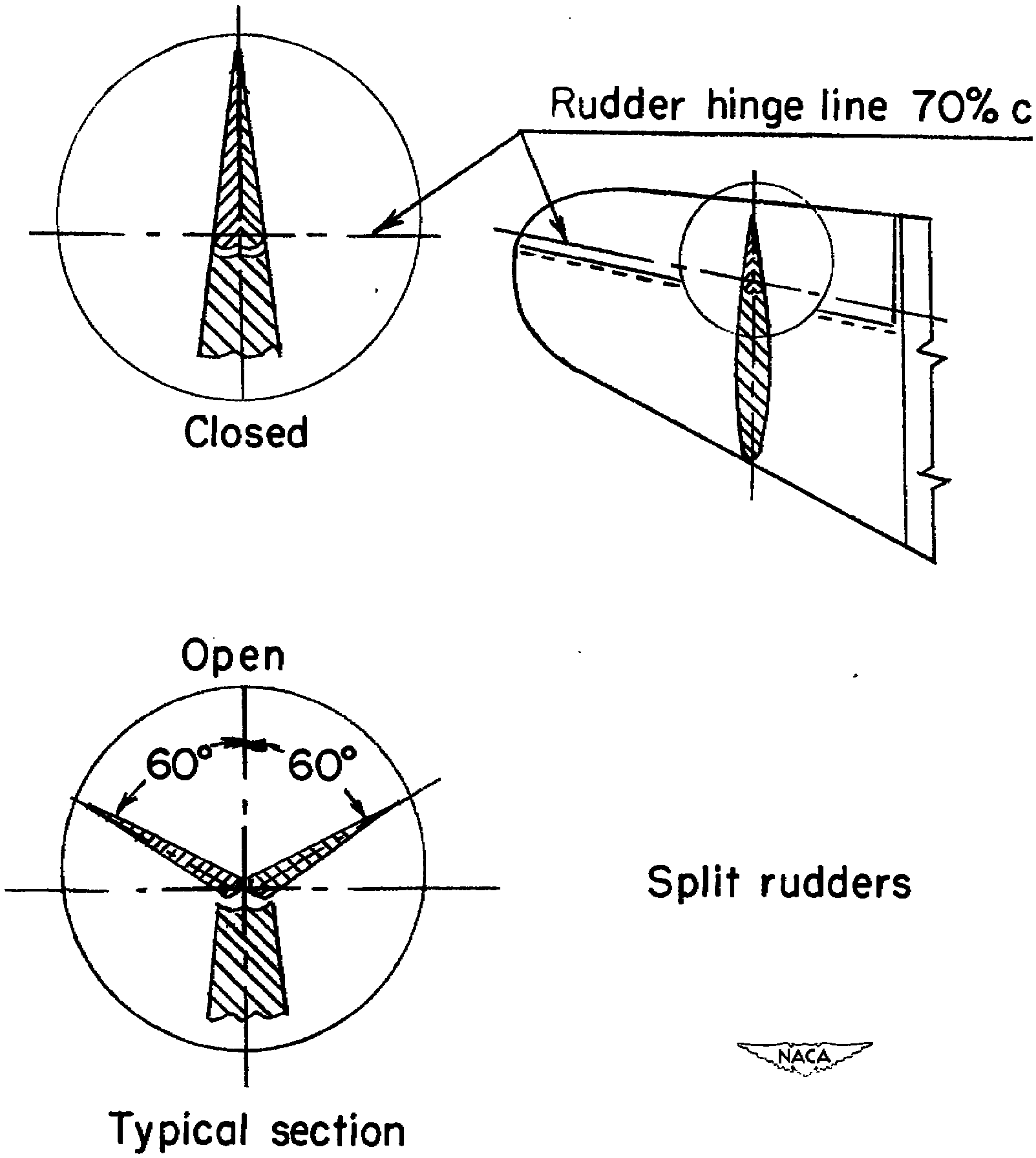
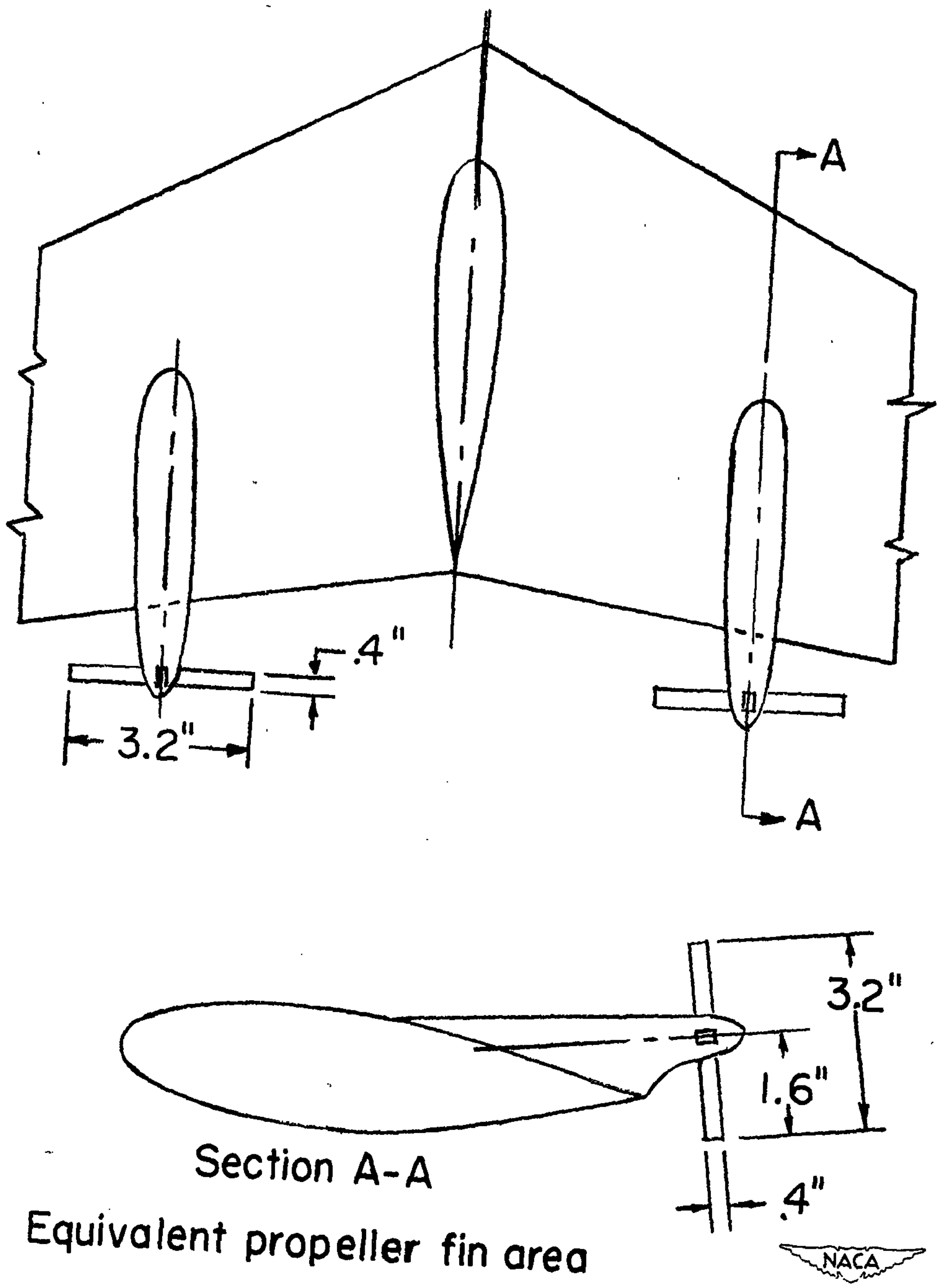



Figure 4.- Concluded.



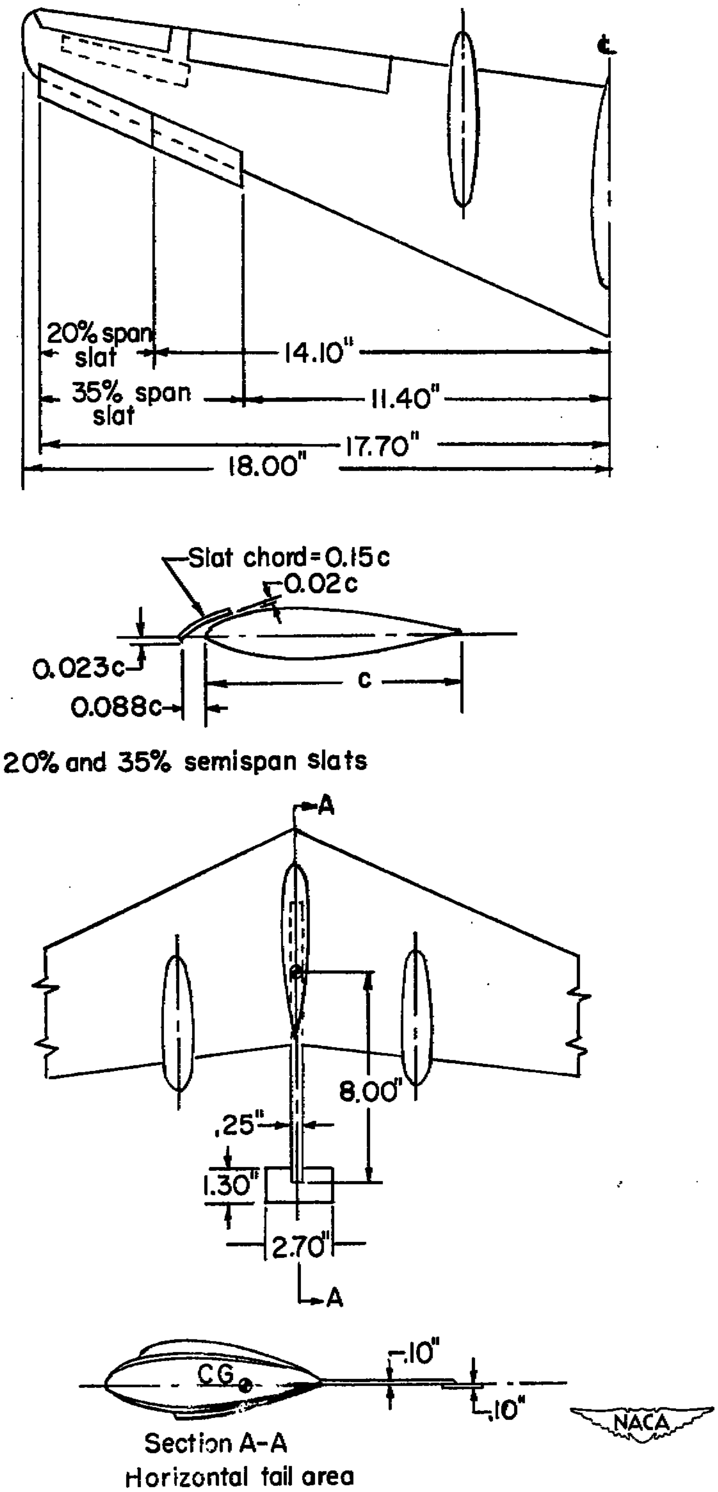

(a) Model 1.

Figure 5.- Modifications tested on models.



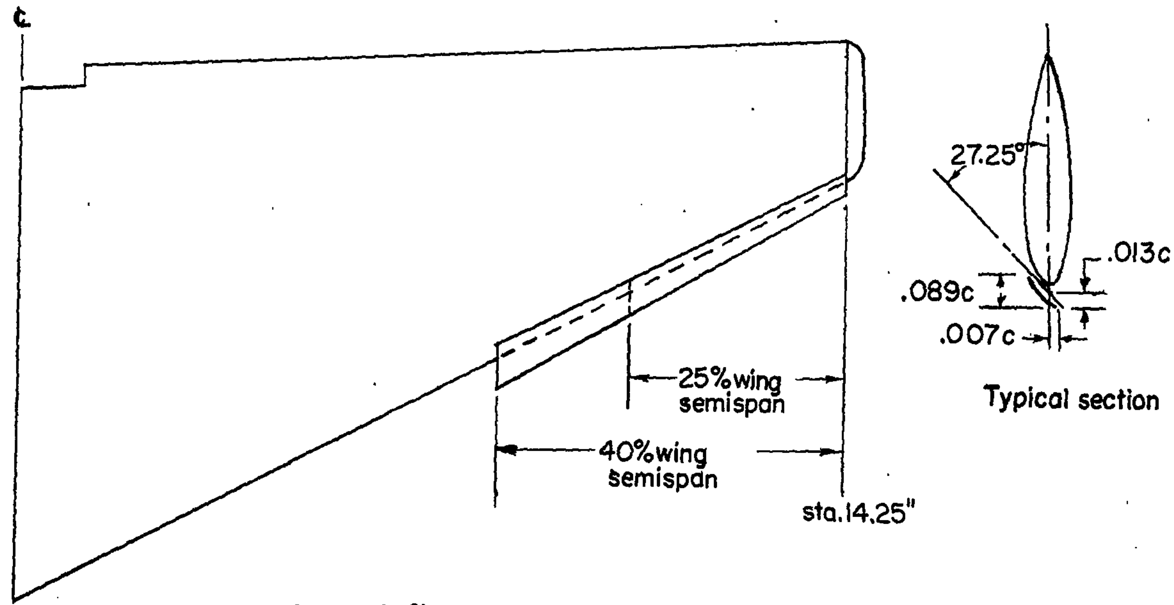

(b) Model 2.

Figure 5.- Continued.

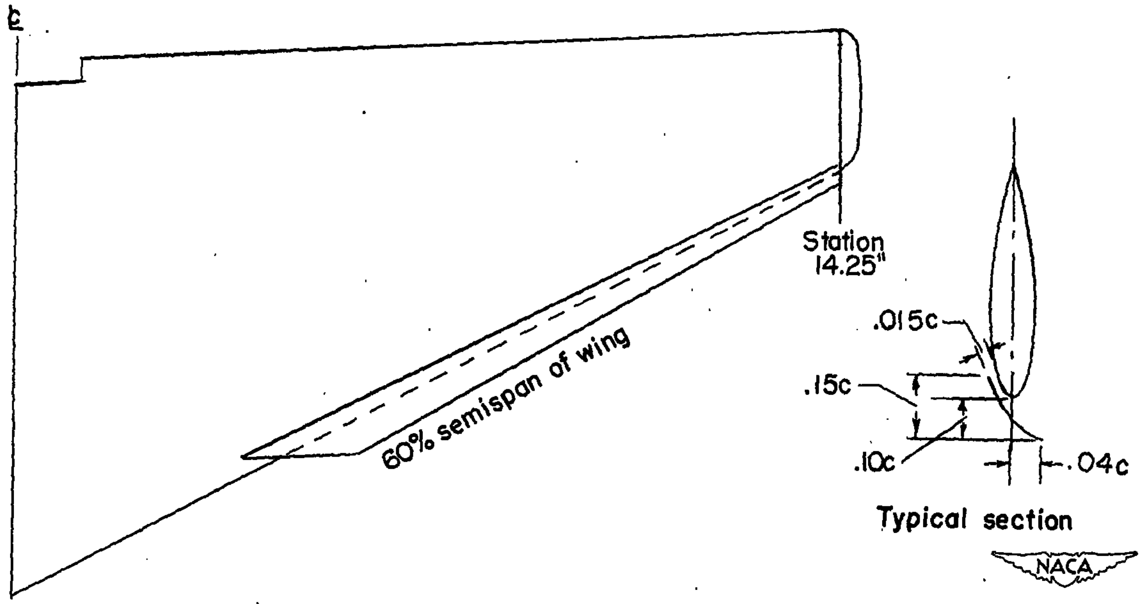



(b) Concluded.

Figure 5.- Continued.



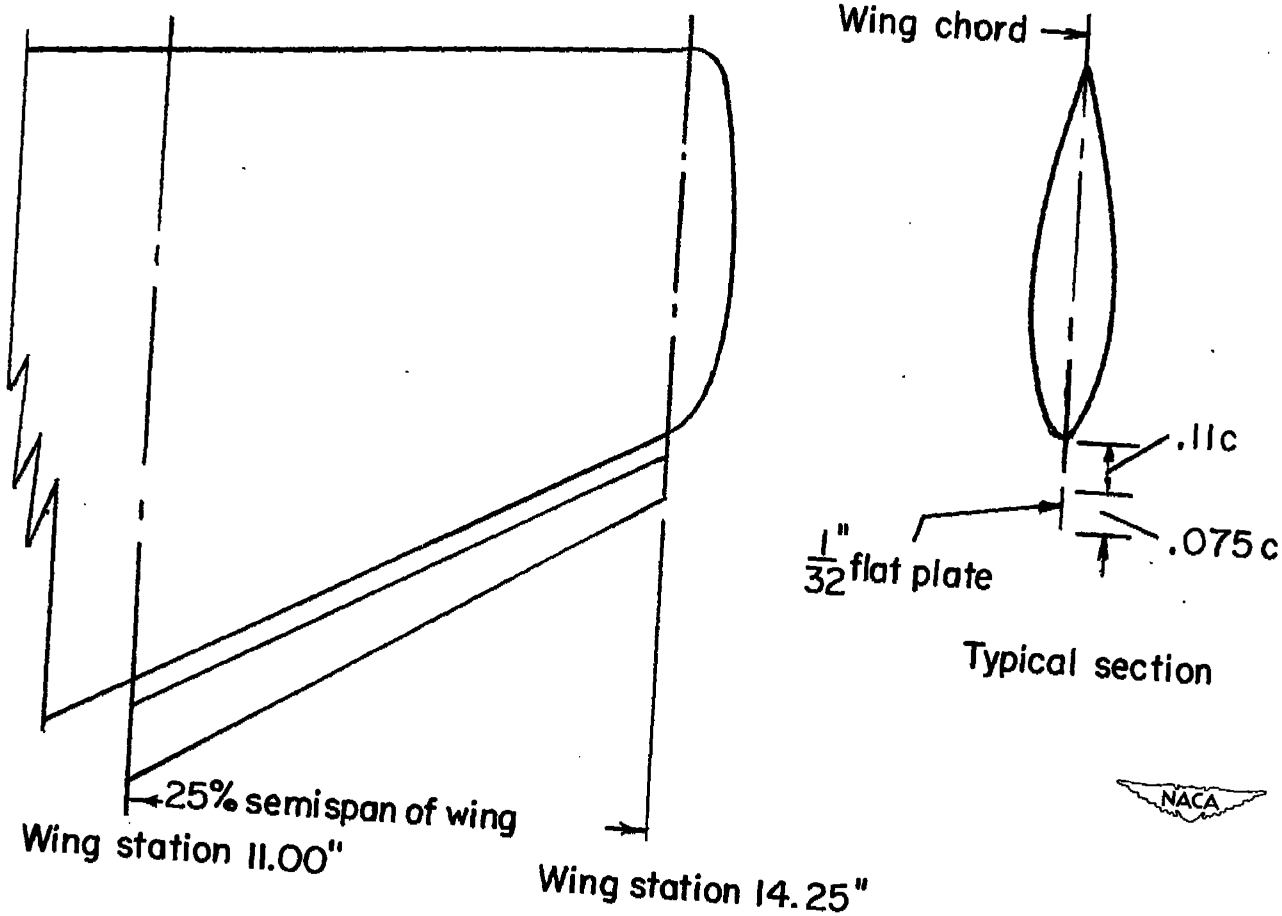

25% and 40% semispan slats




60% semispan slats

(c) Model 4.

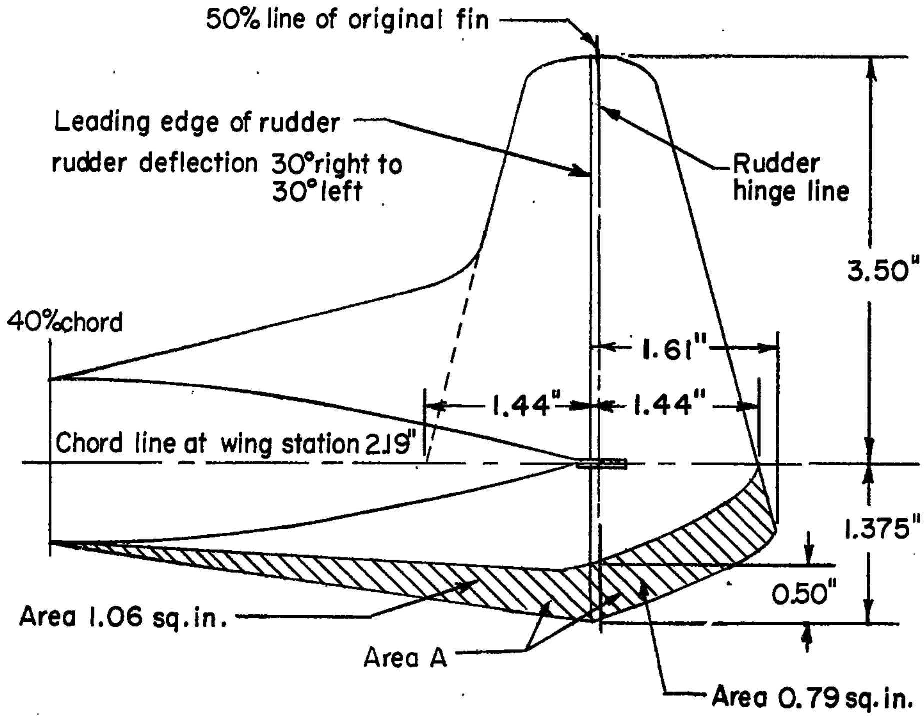
Figure 5.- Continued.



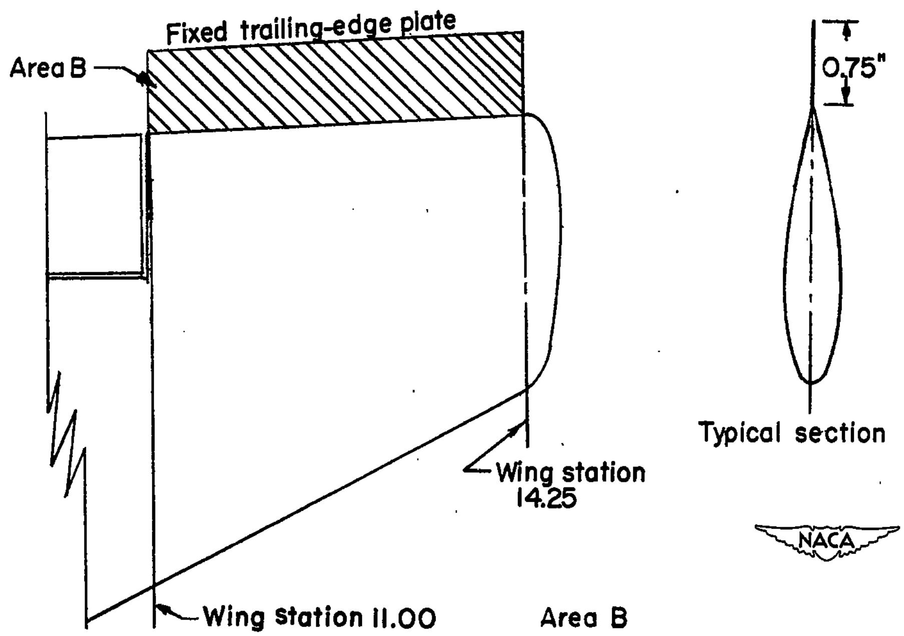

25% semispan auxiliary airfoil slat

(c) Continued.

Figure 5.- Continued.



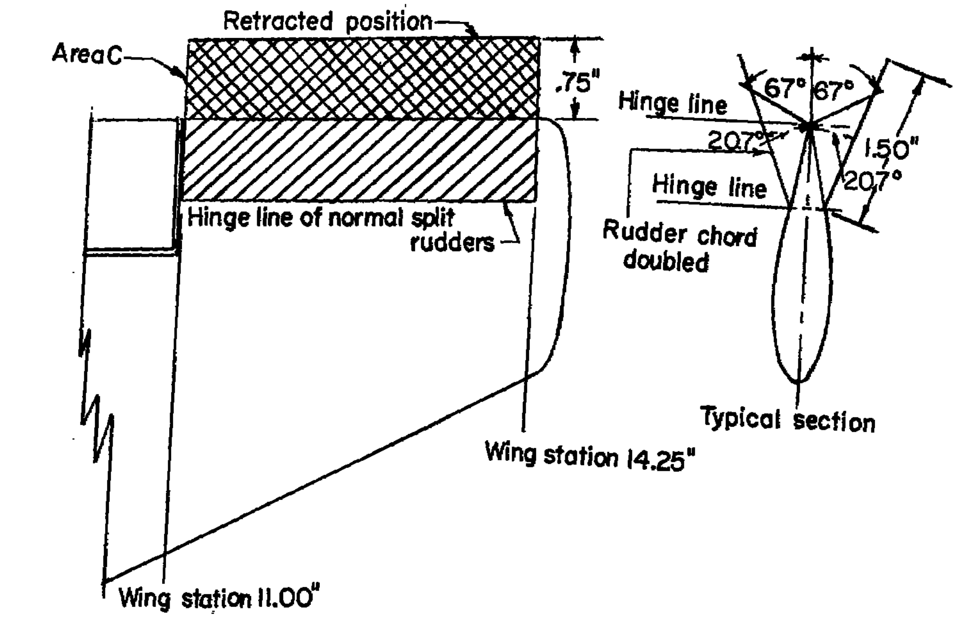

Movable vertical rudder area and ventral fin area A



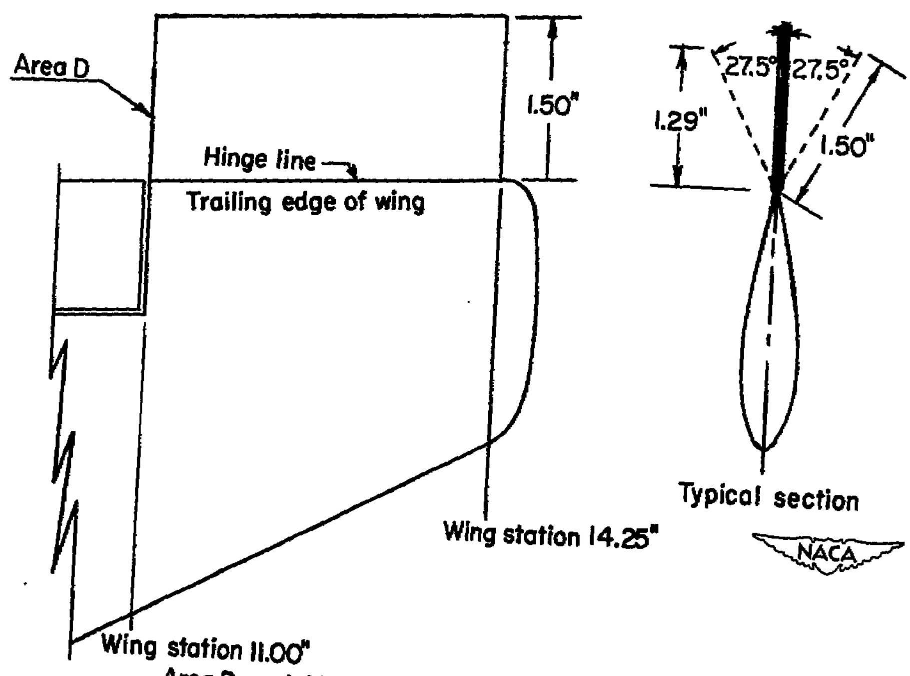

Area B

(c) Continued.

Figure 5.- Continued.



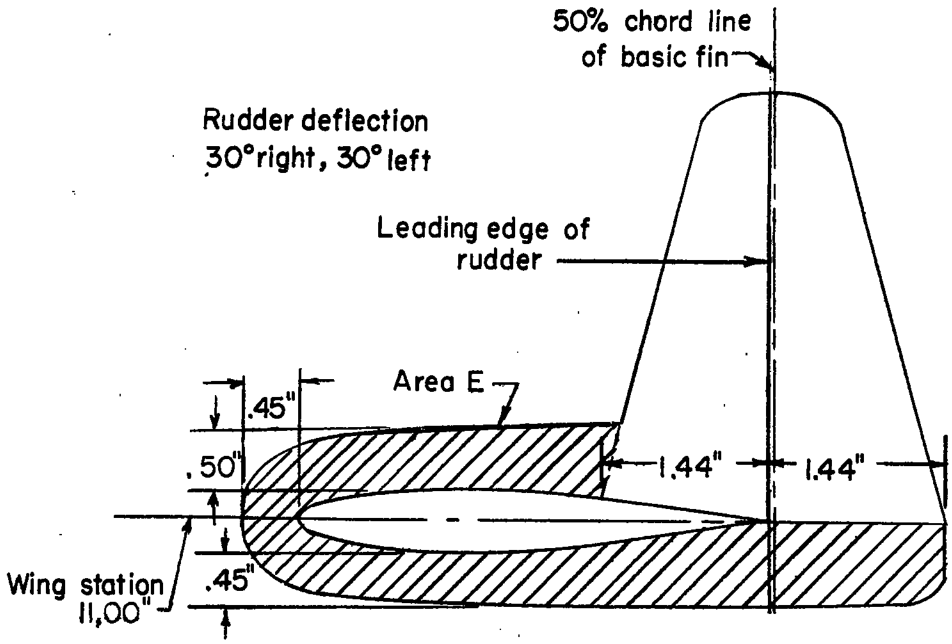

Area C and hinge line moved to trailing edge



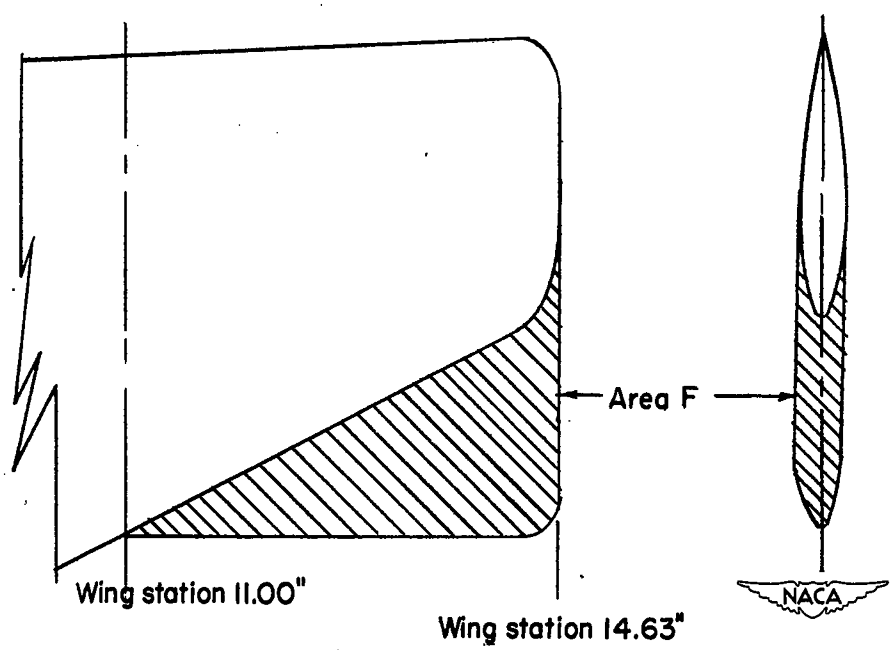

Area D and hinge line moved to trailing edge

(c) Continued.

Figure 5.- Continued.




Area E




Area F

(c) Continued.

Figure 5.- Continued.

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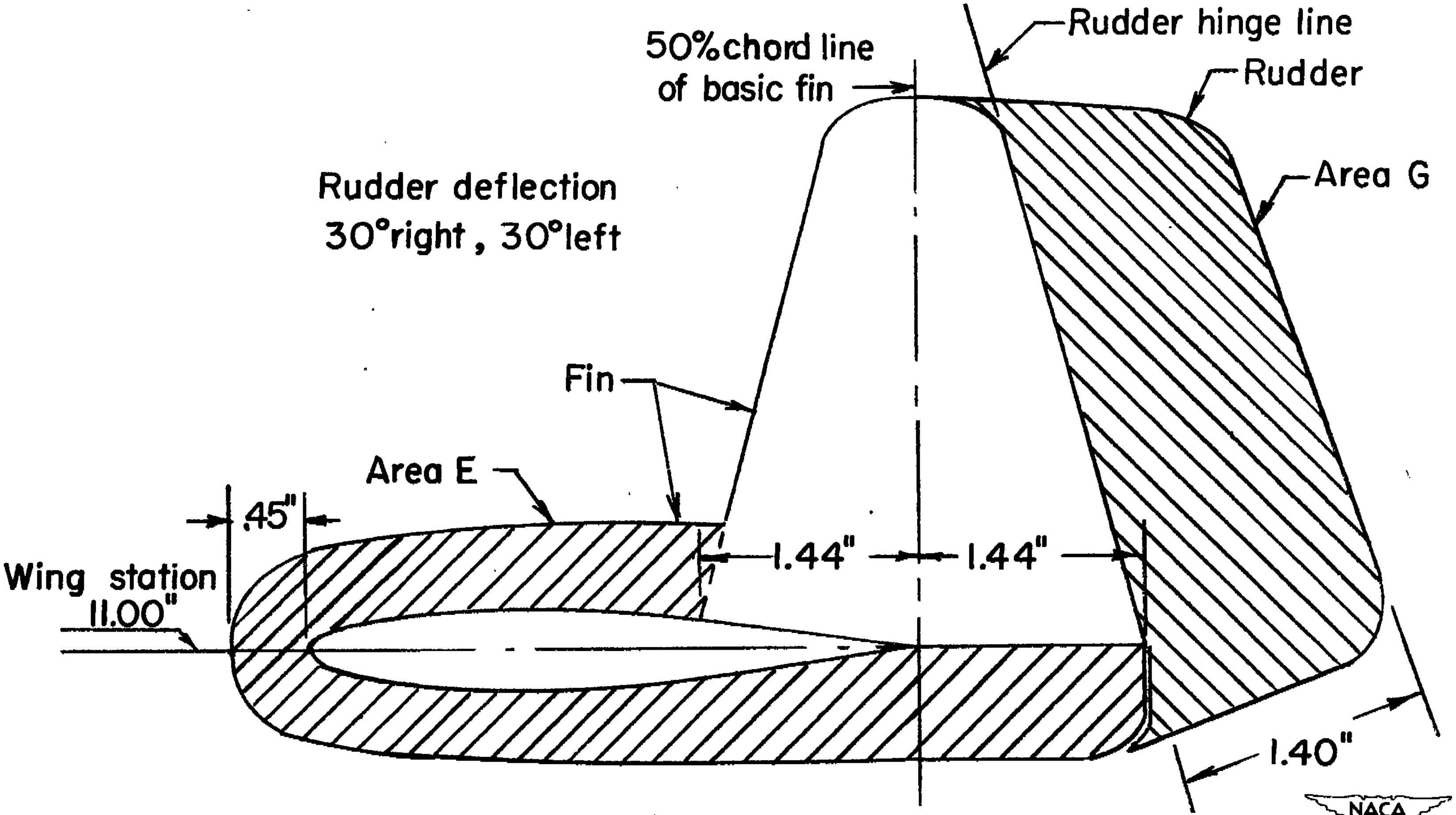


Area E and G

(c) Concluded.

Figure 5.- Continued.

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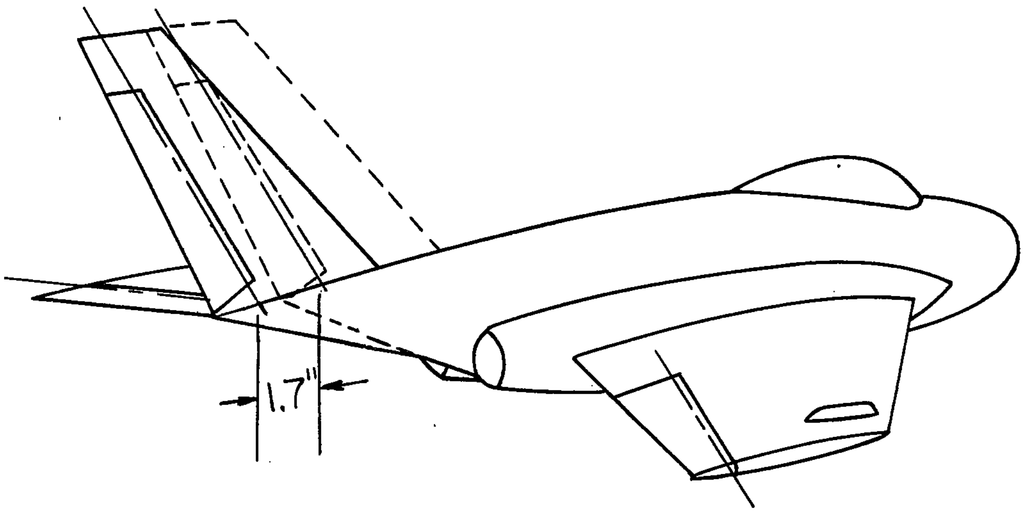
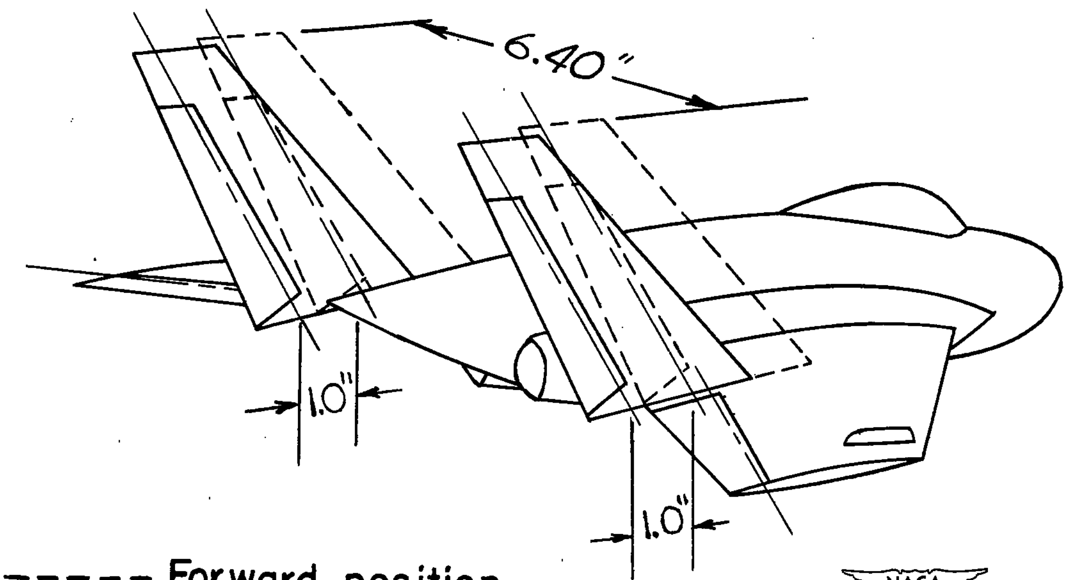



------ Original position
——— Rearward position

Single vertical tail moved rearward

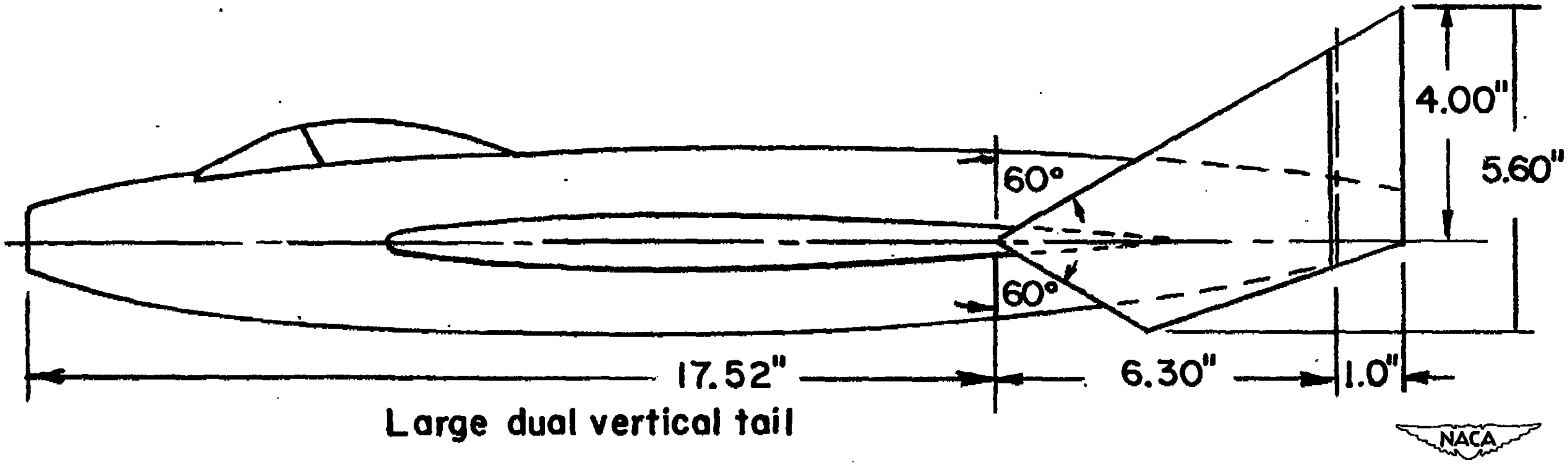



----- Forward position
——— Rearward position

Dual vertical tails in forward and rearward positions

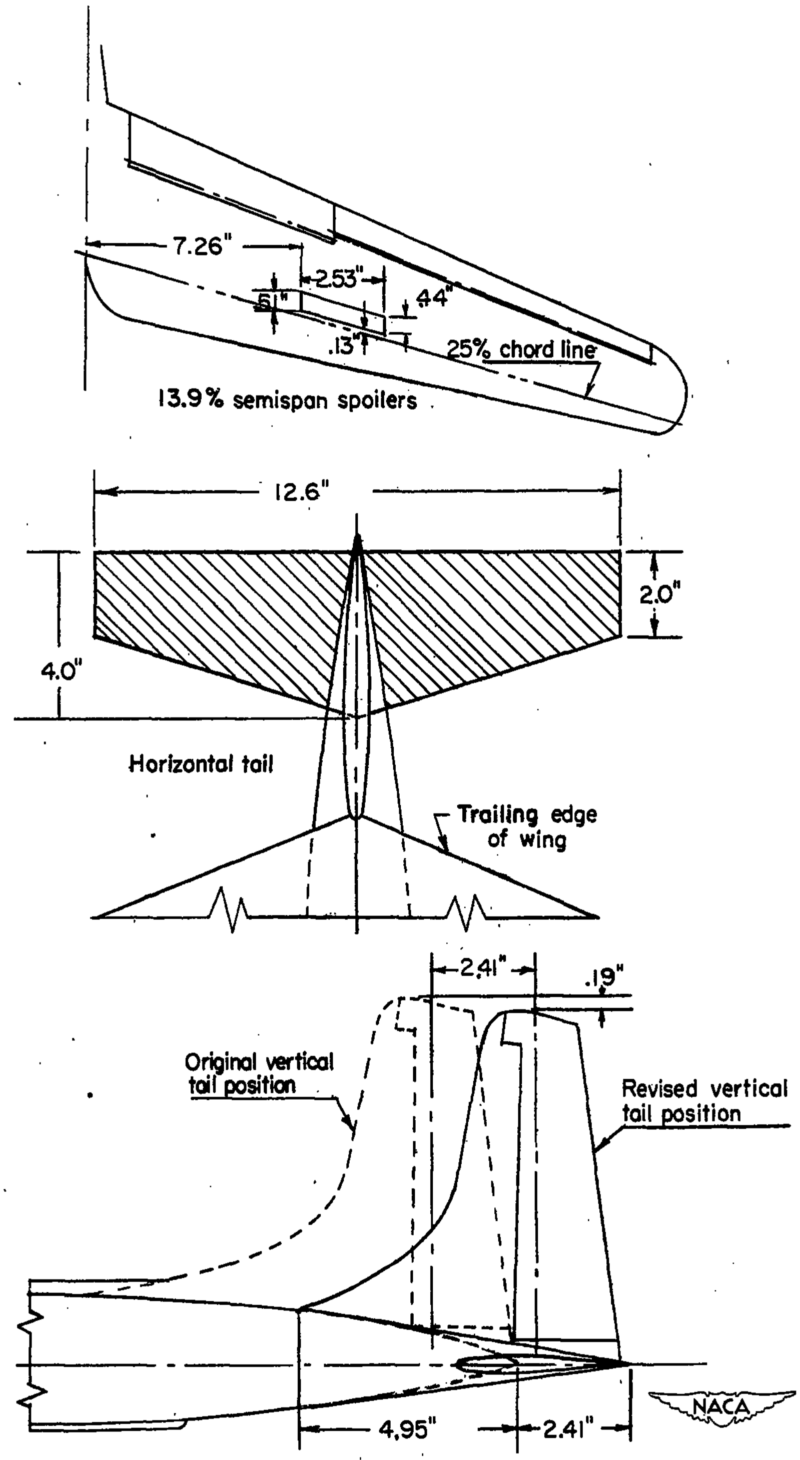
(d) Model 6.

Figure 5.- Continued.




(e) Model 7.

Figure 5.- Continued.




Increased vertical tail length with horizontal tail added.

(f) Model 8.

Figure 5.- Continued.

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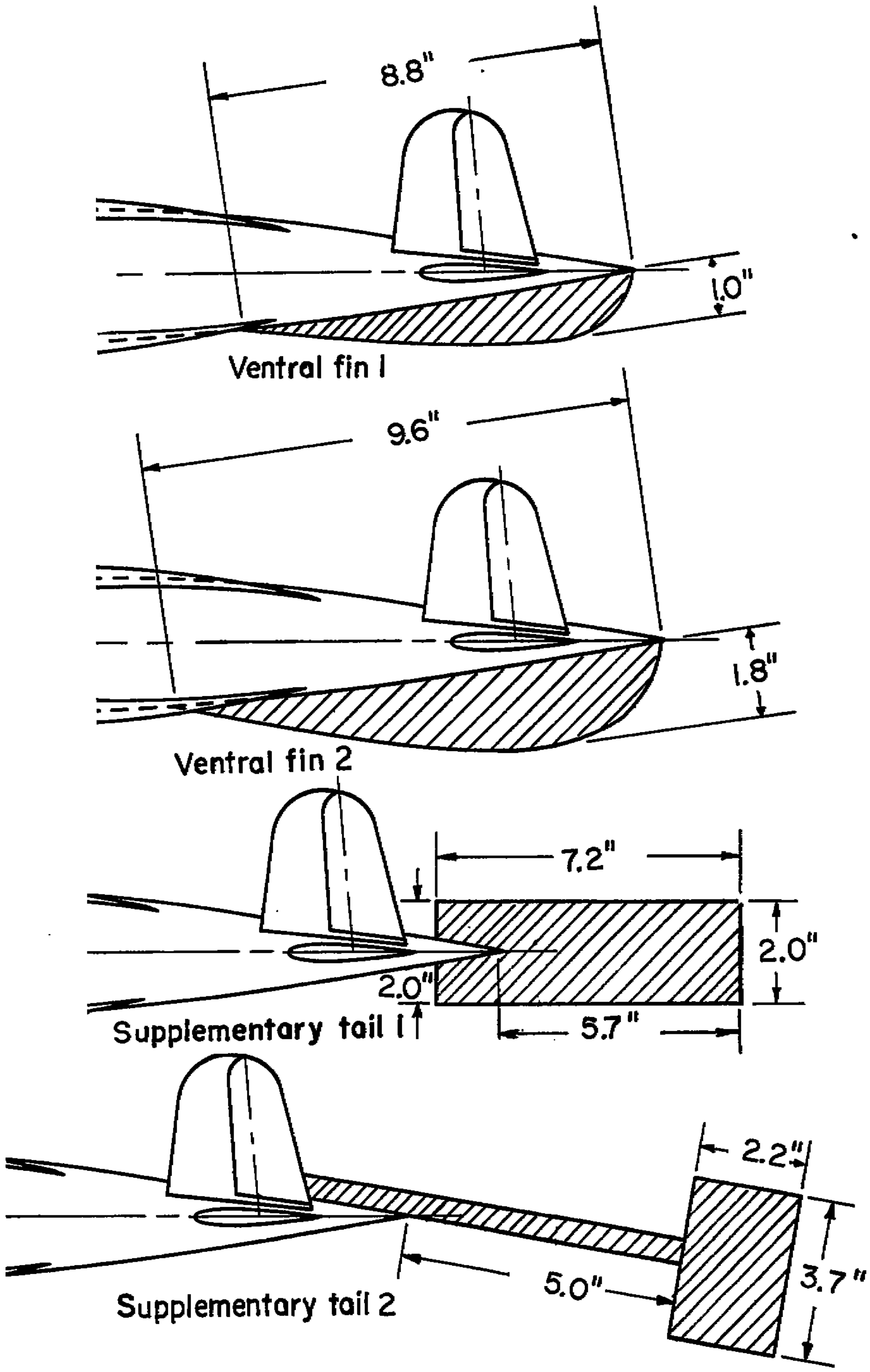
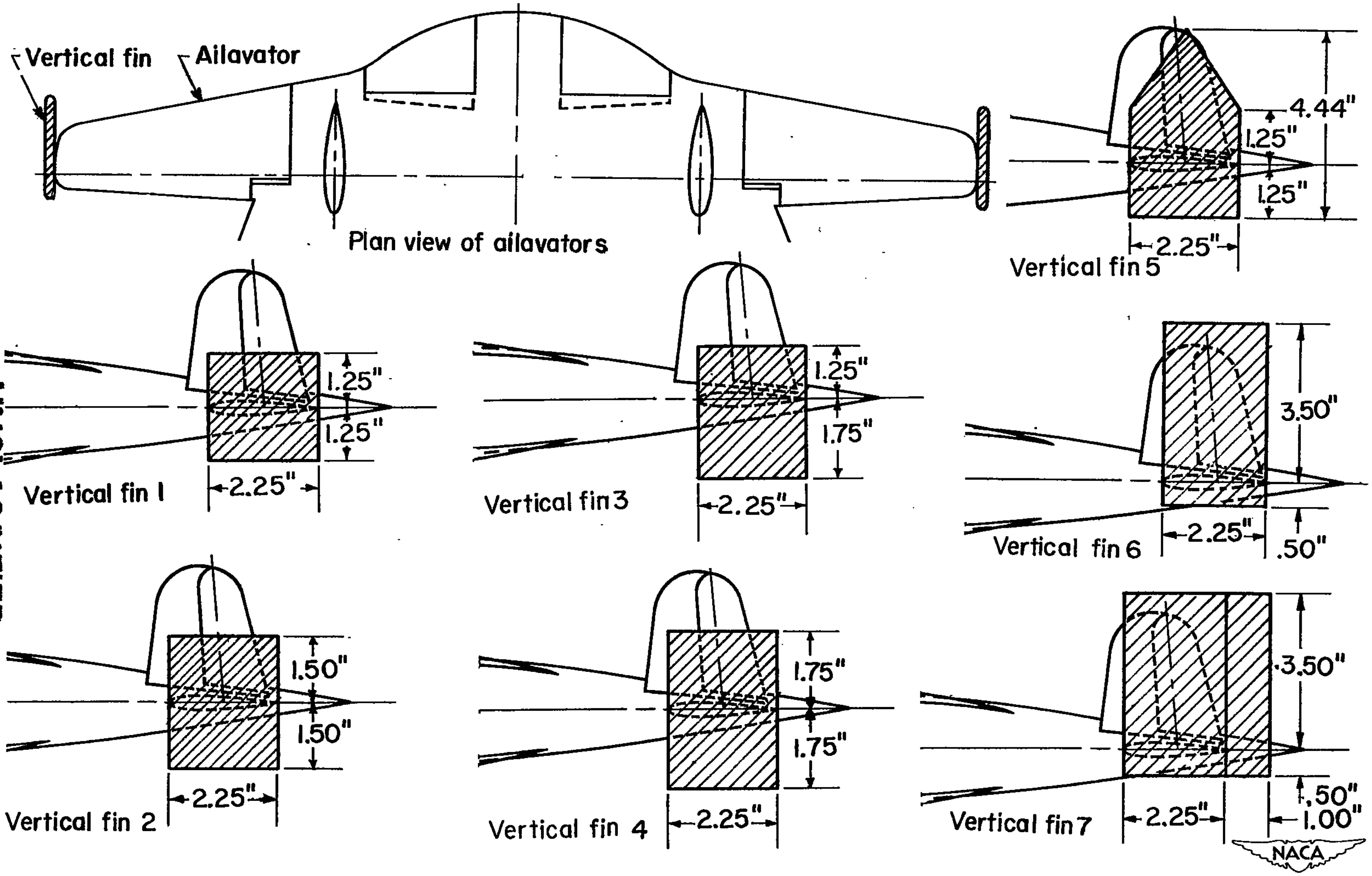
[redacted]




Ventral fins and supplementary tails added in plane of symmetry

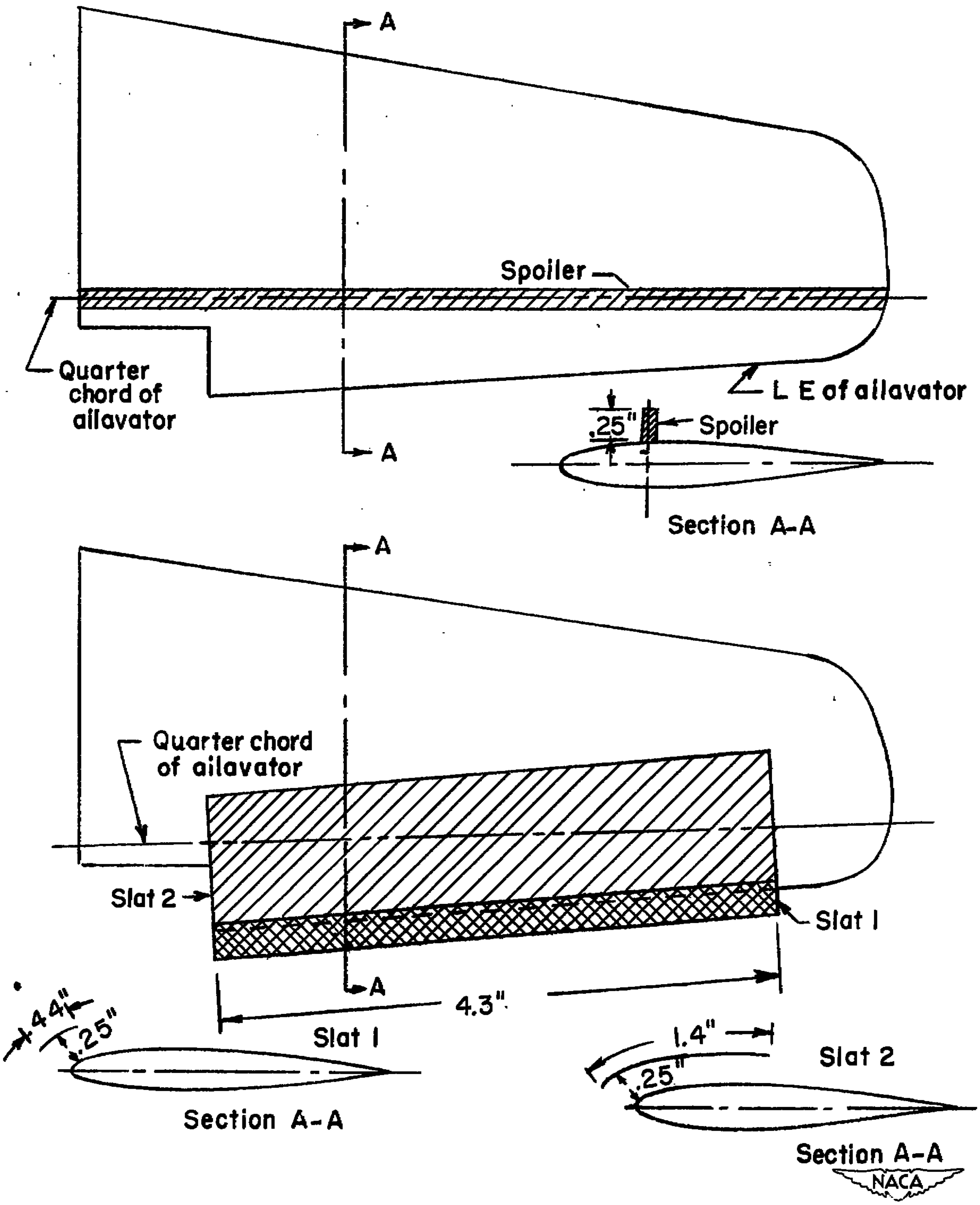
(g) Model 10.

Figure 5.- Continued.



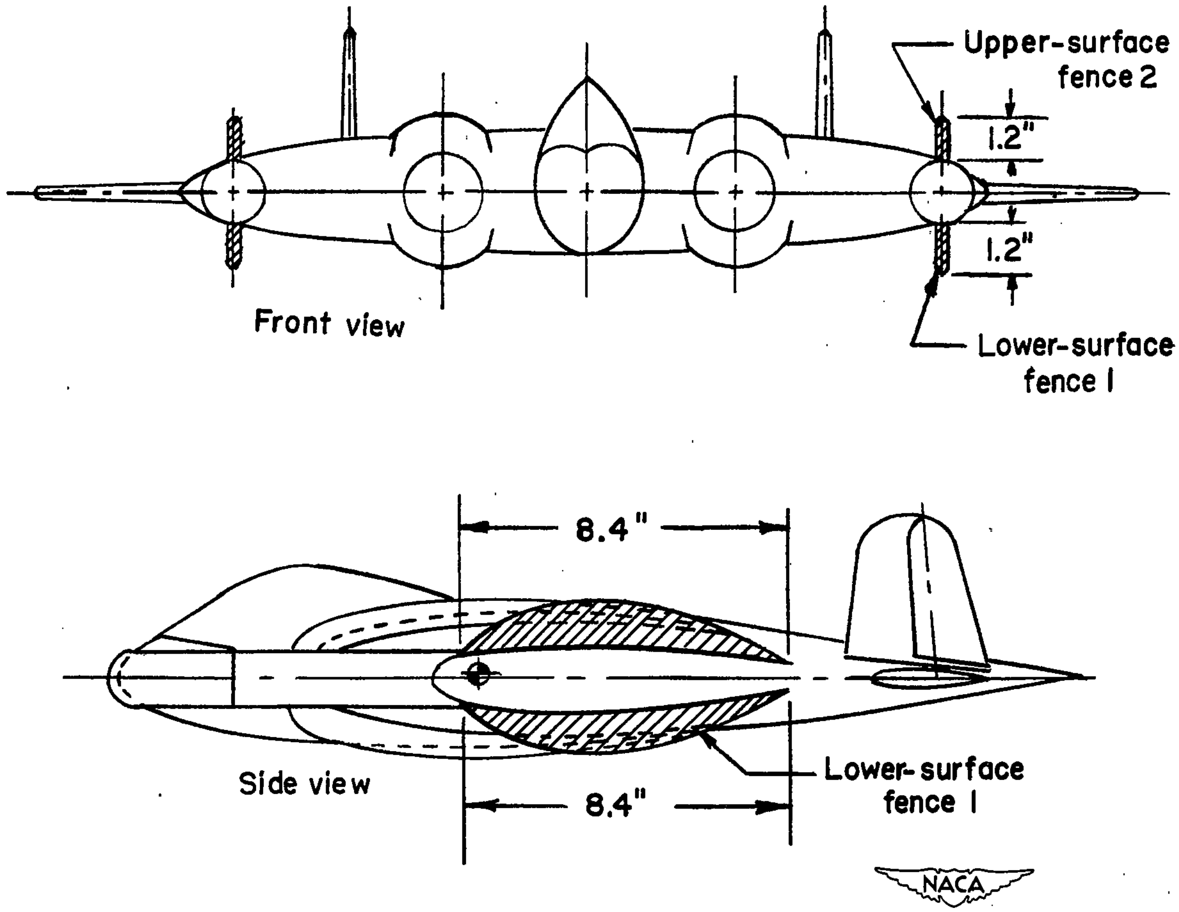

(g) Continued.

Figure 5.- Continued.



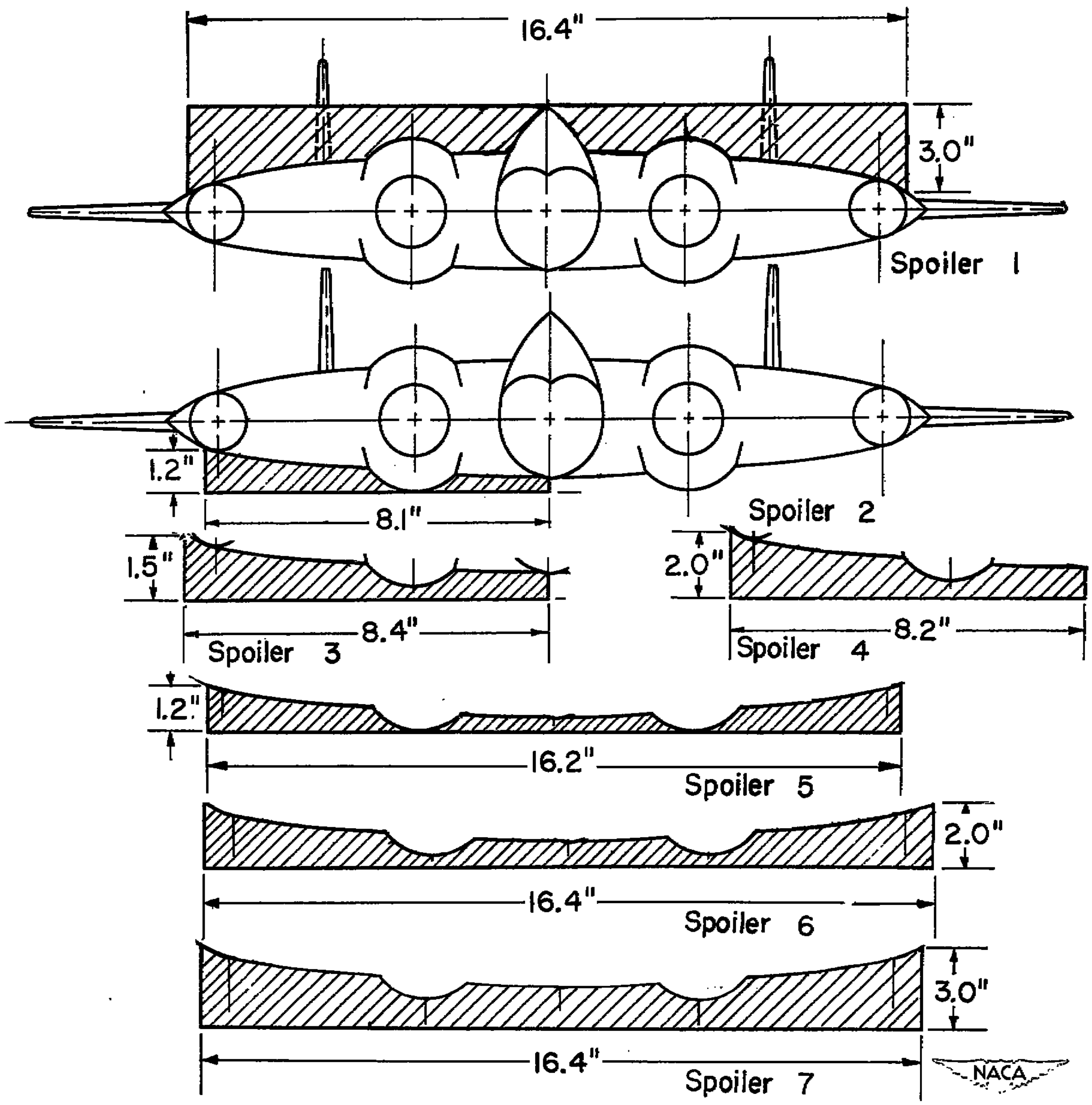

(g) Continued.

Figure 5.- Continued.




(g) Continued.

Figure 5.- Continued.




Spoilers added at c/4 line

(g) Continued.

Figure 5.- Continued.

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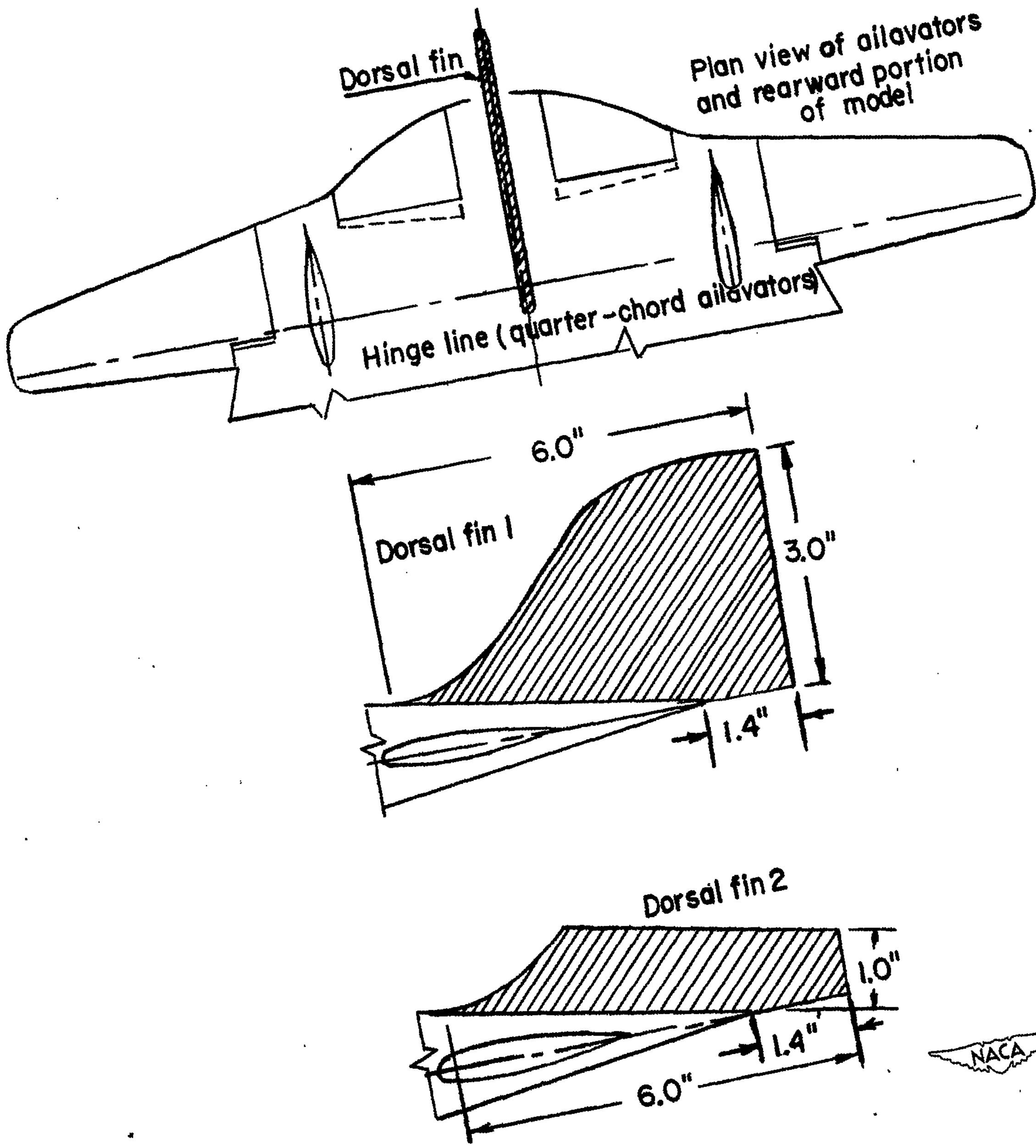


(g) Concluded.

Figure 5.- Continued.

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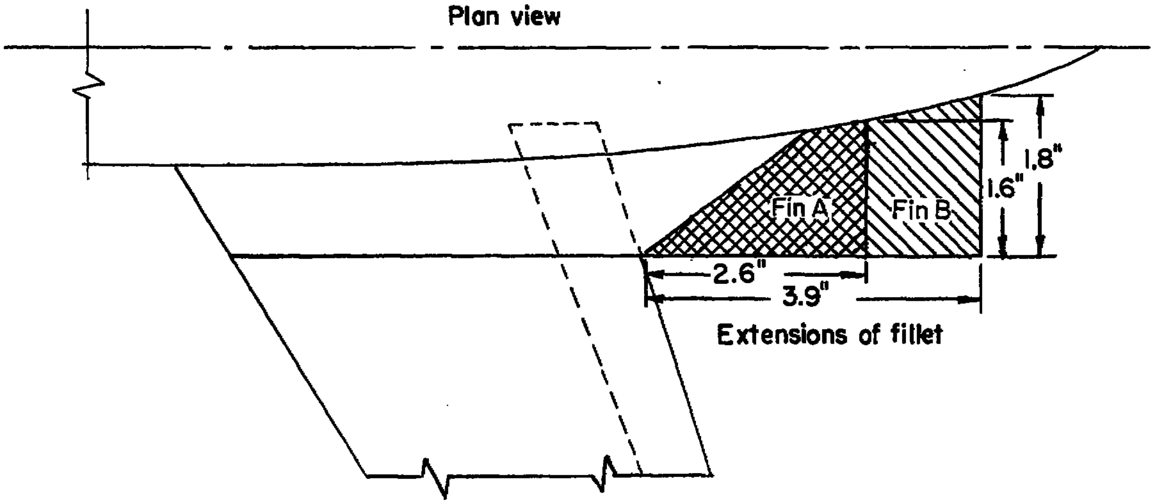
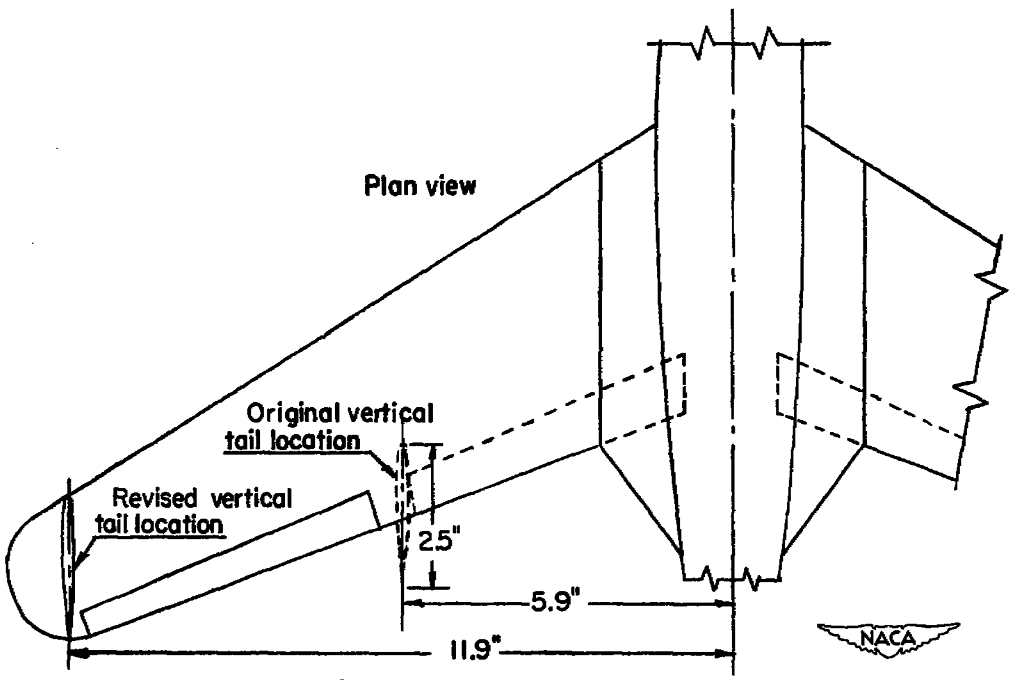


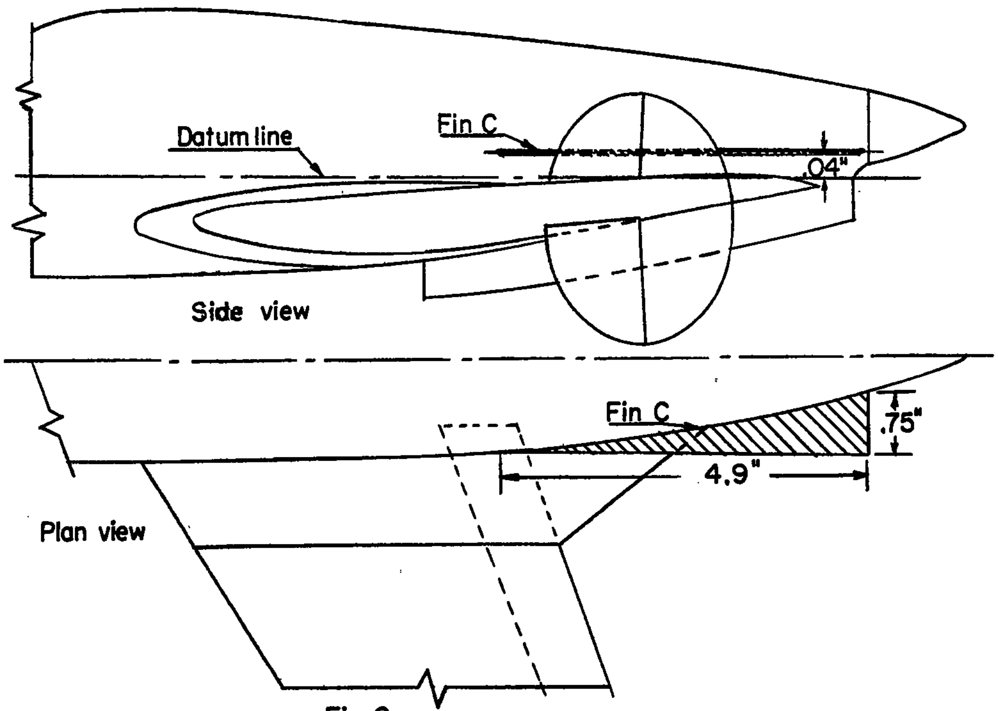

Fins A and B



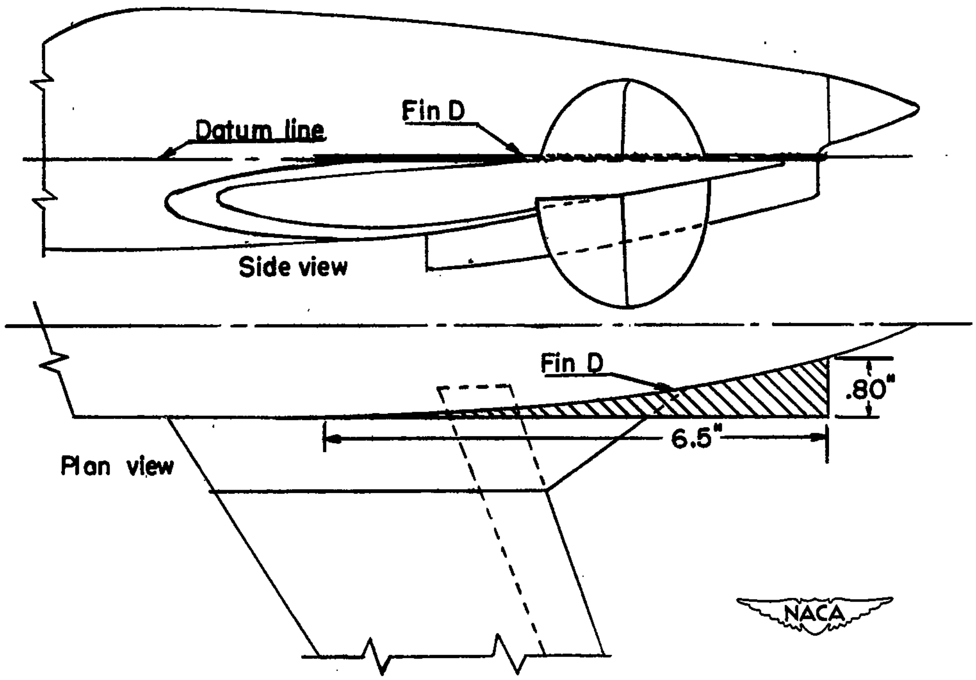

Revised vertical tail location

(h) Model 11.

Figure 5.- Continued.




Fin C




Fin D

(h) Continued.

Figure 5.- Continued.

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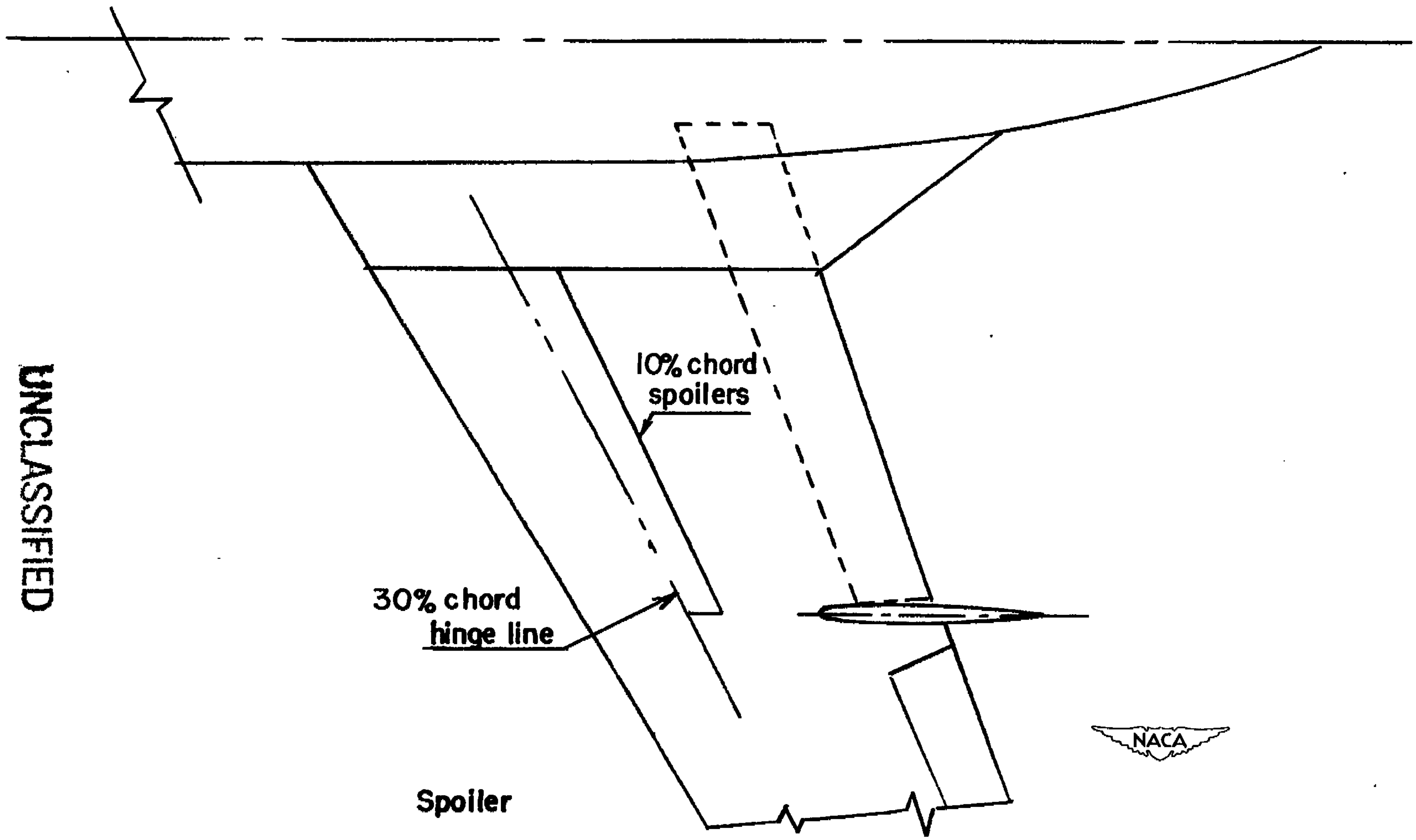


(h) Concluded.

Figure 5.- Concluded.

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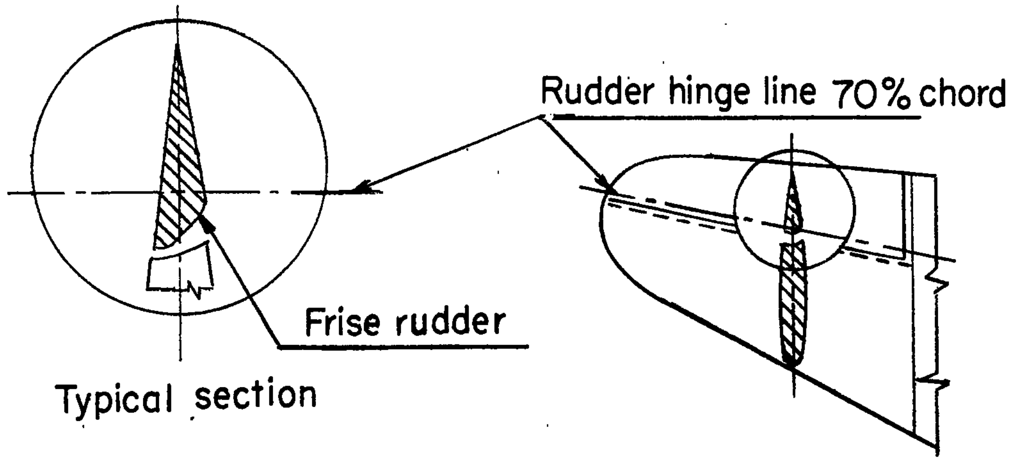
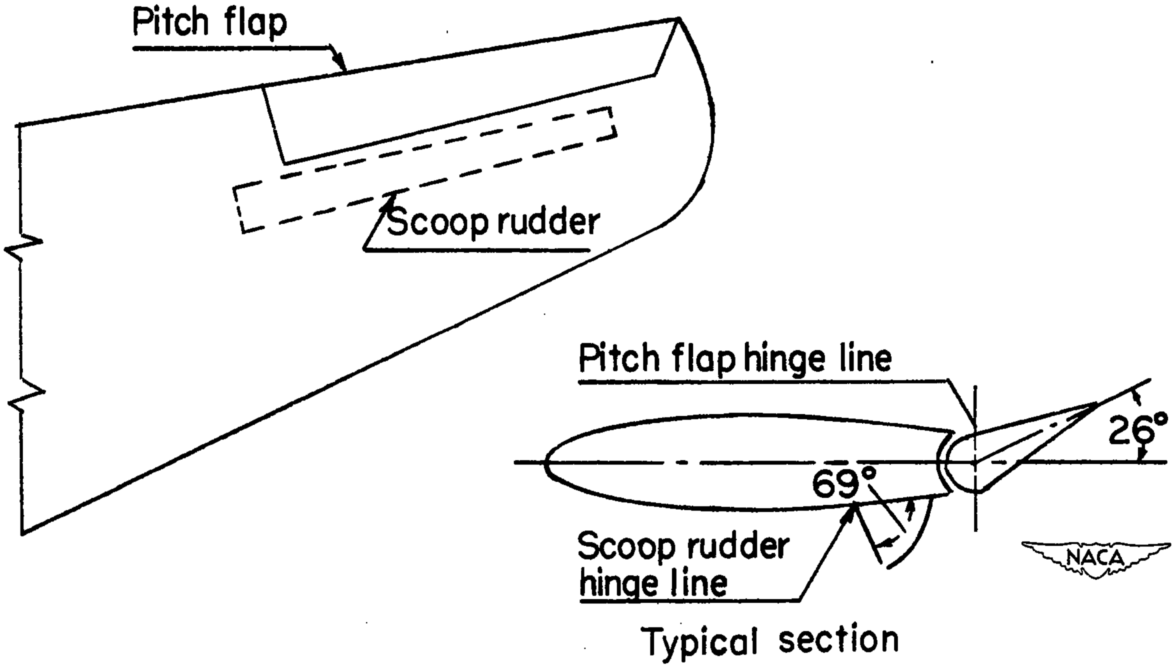
[redacted]

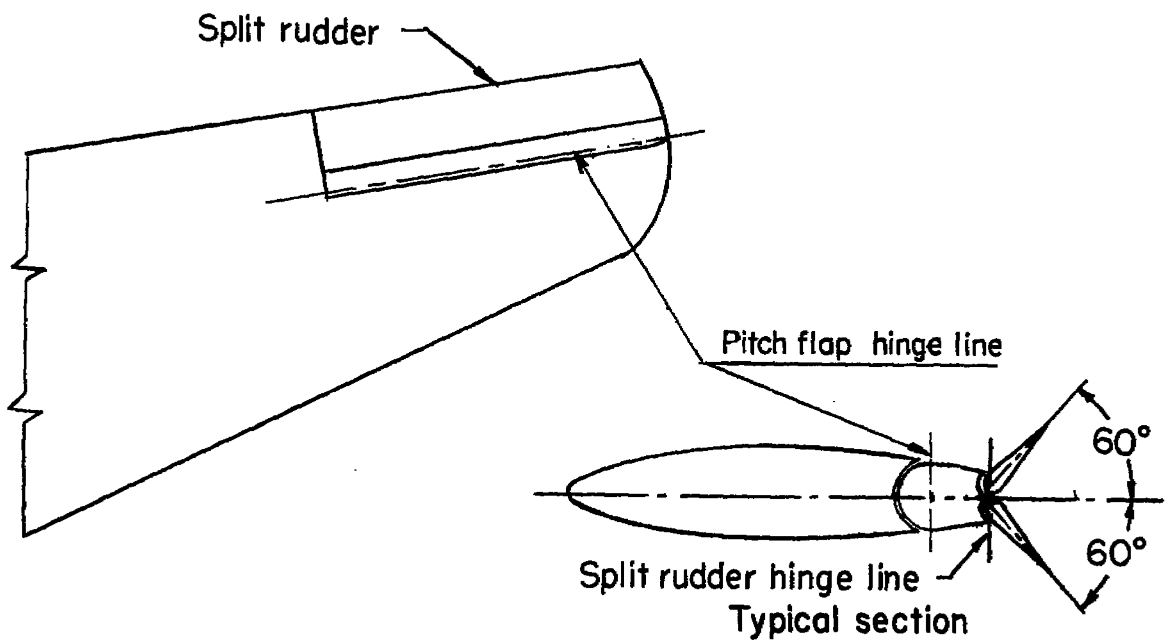



(a) Rudder detail for model 1.

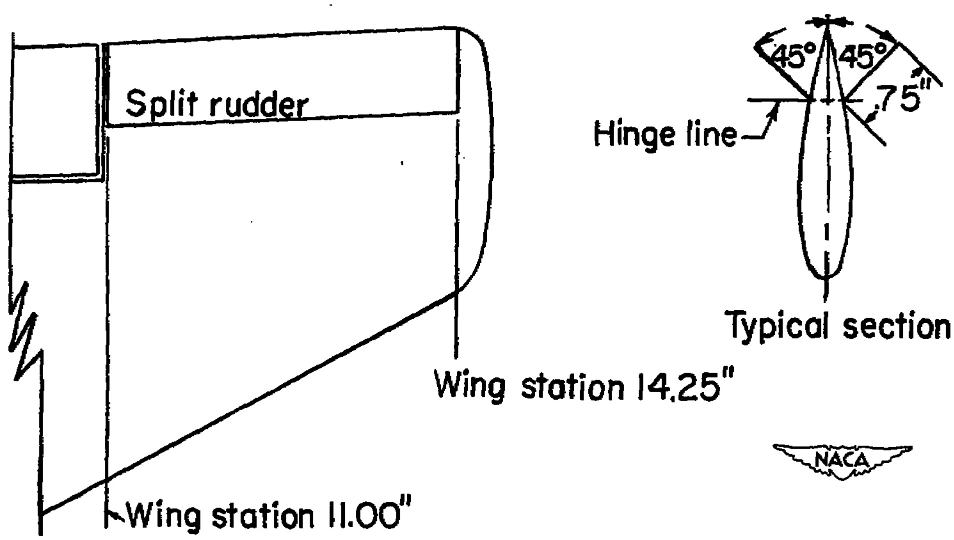



(b) Rudder detail for model 2.

Figure 6.- Details of drag-type rudders used on models 1 to 4.

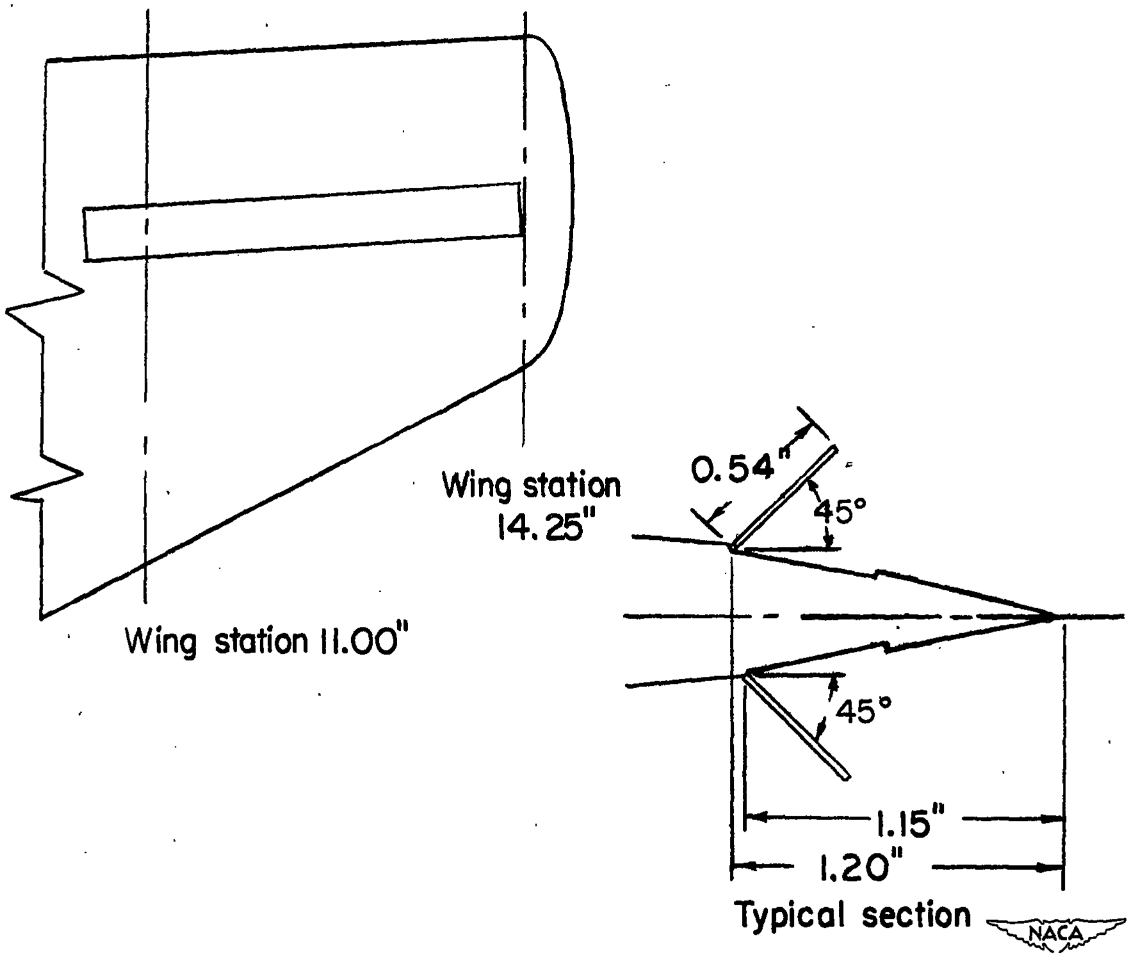



(c) Rudder details for model 3.




(d) Rudder details for model 4; split-type rudders.

Figure 6.- Continued.




(e) Rudder detail for model 4; alternate circular-arc type rudder.

Figure 6.- Concluded.

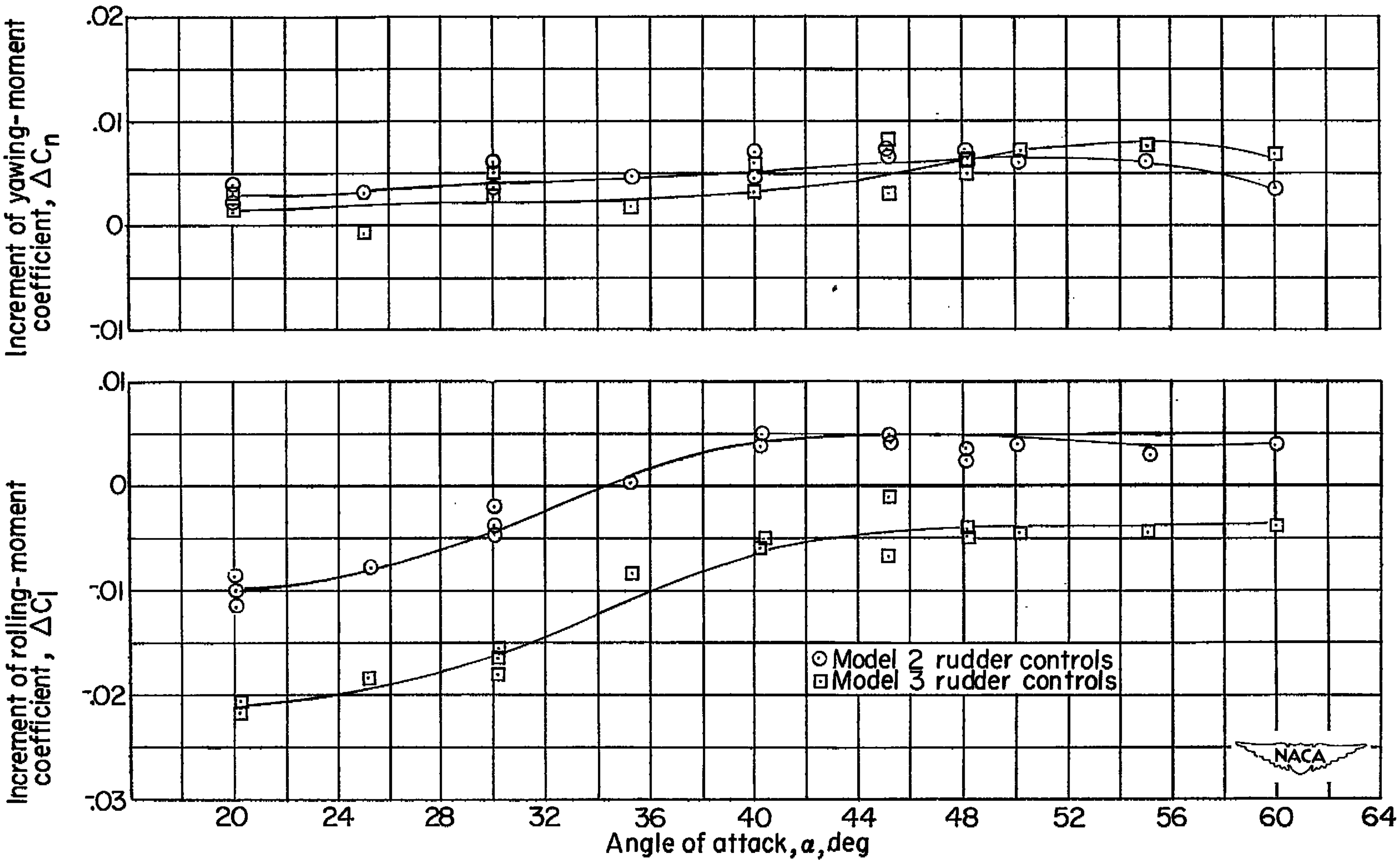



Figure 7.- Increments of yawing- and rolling-moment coefficients contributed by models 2 and 3 rudder controls as a function of angle of attack. Rudder controls on right wing tip fully deflected; rudder controls on left wing tip neutral; q = 4.274.

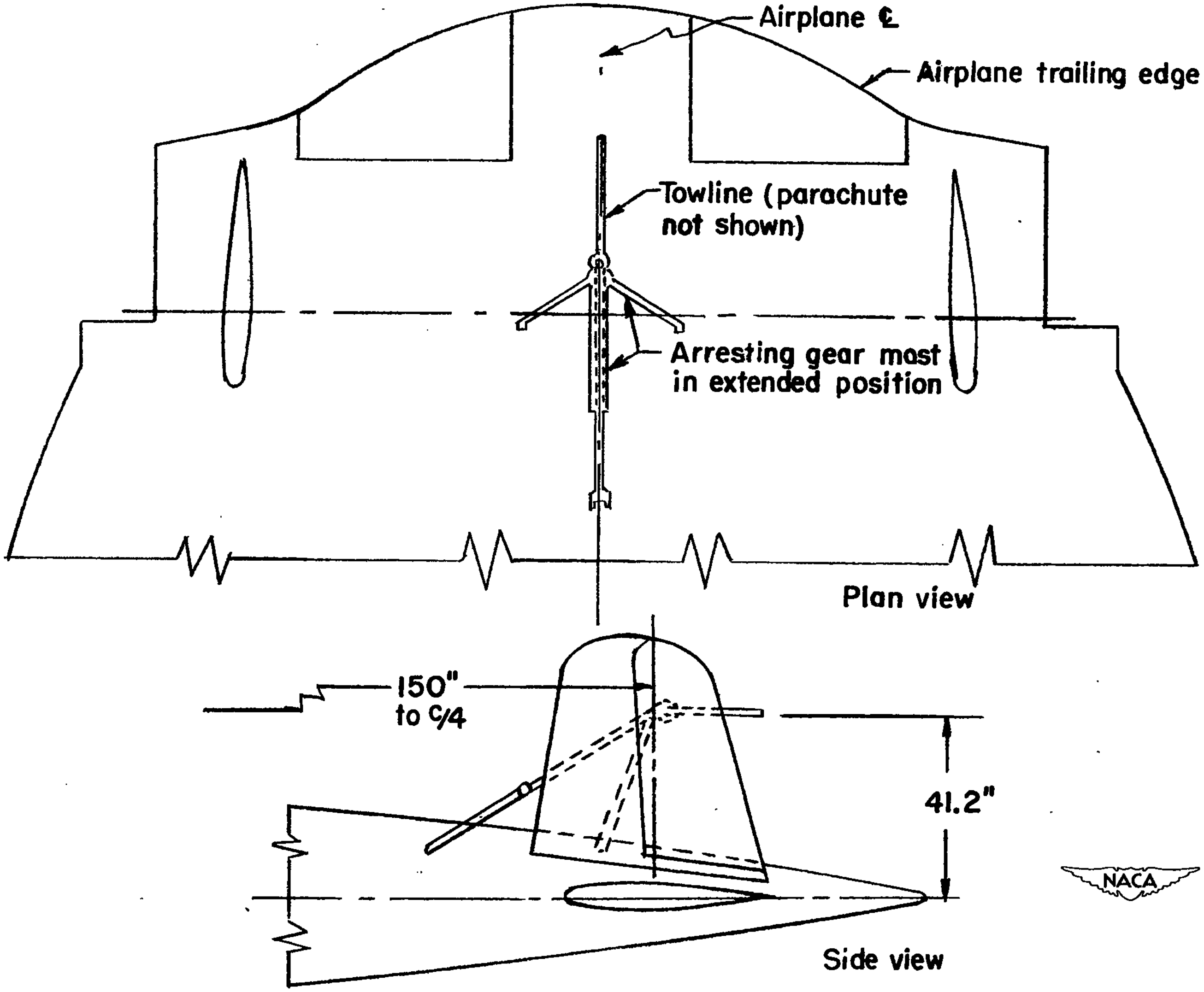



Figure 8.- Arresting gear mast for tail parachute attachment of model 10.